

New Scientist

WEEKLY 4 November 2023

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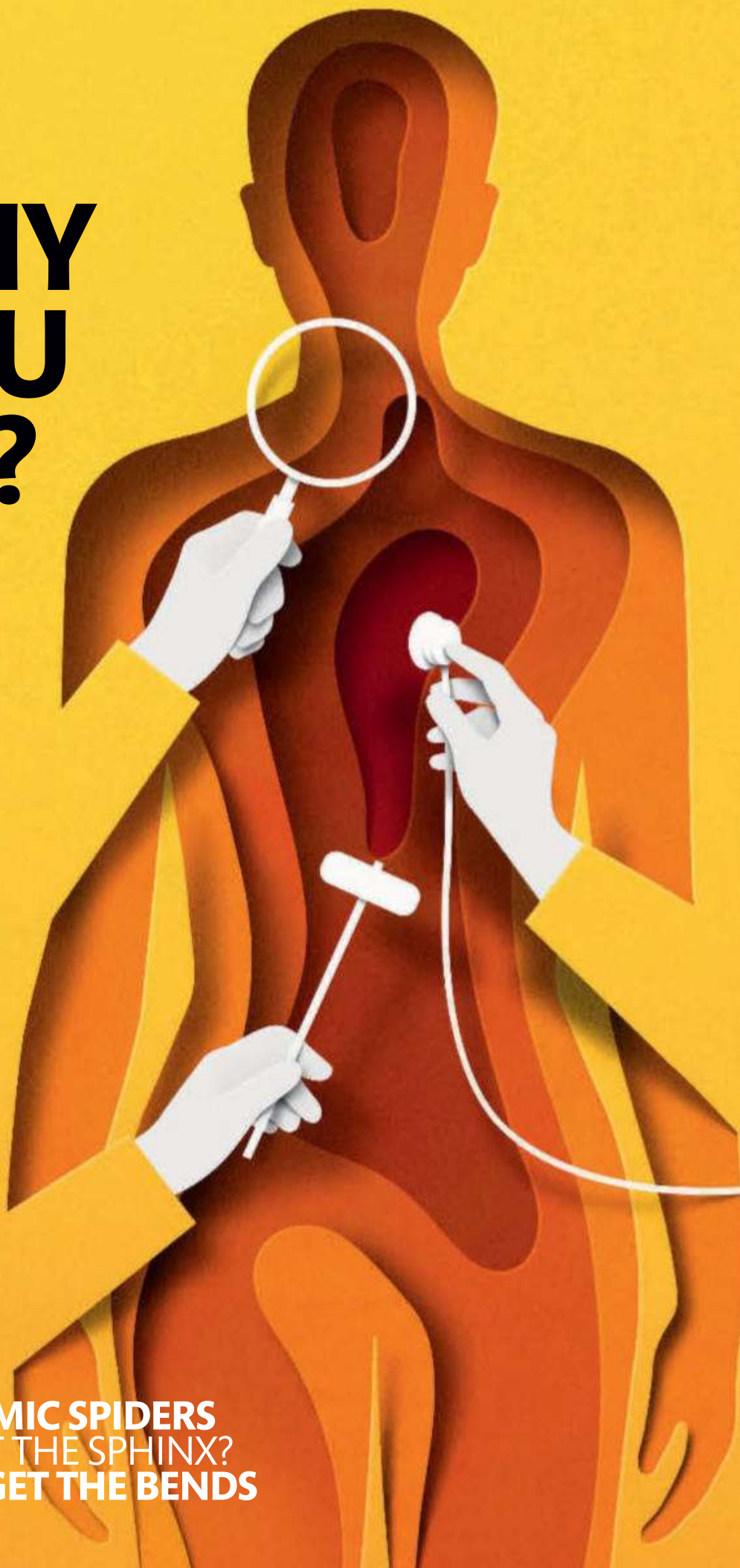
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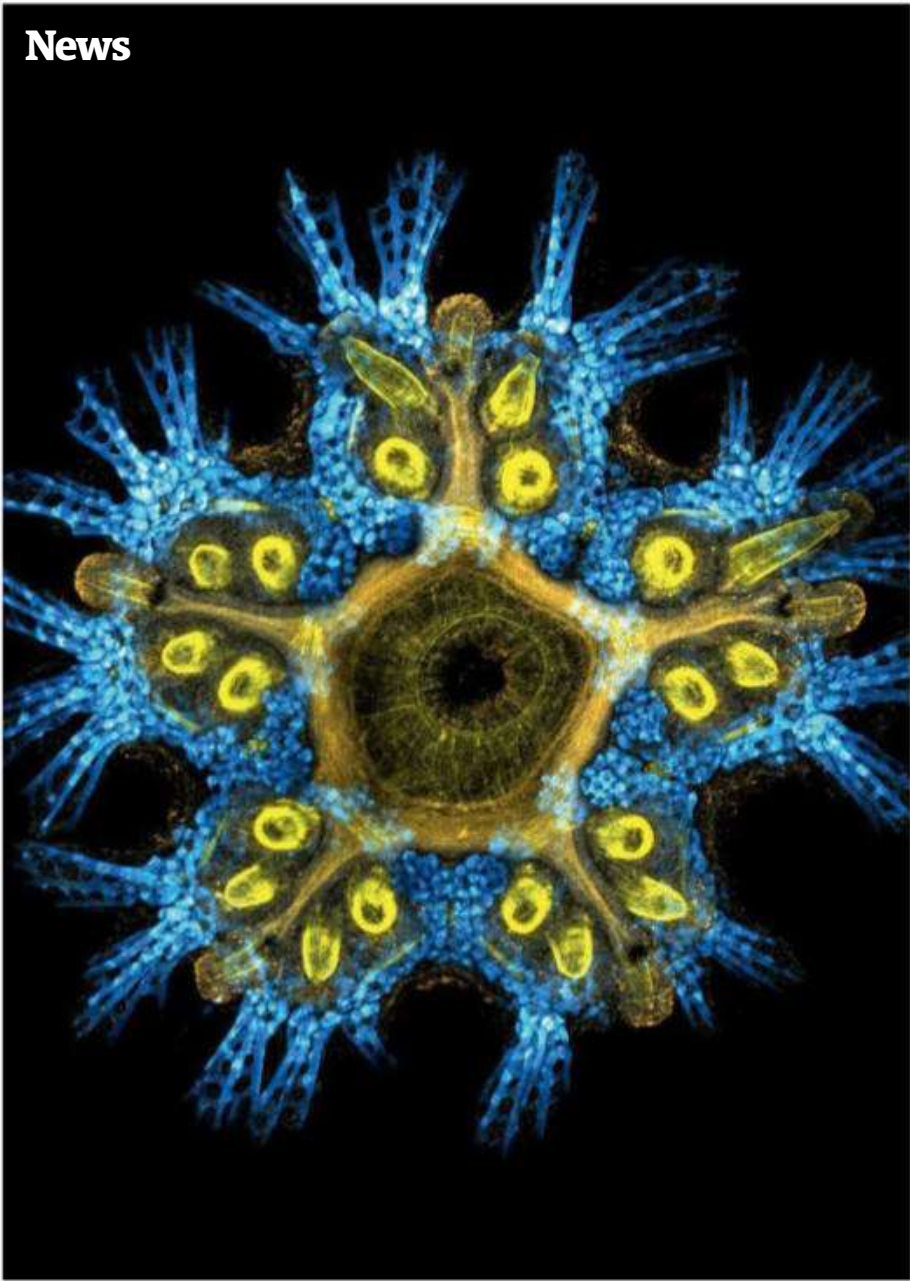
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Artificial intelligence

Following the release of ChatGPT, there has been an explosion of interest in generative AIs that create text or images. But how do these systems work? And what are the ethical, social and political challenges raised? Join our expert speakers in London on 25 November to hear about advances in natural language processing, computer vision and AIs for the creative arts.

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Tour

Whale watching in the Azores: Portugal

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Podcast

Weekly

In this episode, the team find out if chickens can recognise themselves in a mirror. They reveal that the number of qubits in a quantum computer has recently doubled and discuss if other mammals experience menopause as humans and whales do. Plus, hear how smart glasses can mimic echolocation for people who are blind.

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Dolphin watching Take part in marine research on an Azorean tour



Great Red Spot Jupiter has the strongest winds in the solar system

Video

TikTok

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Newsletter

Launchpad

Jupiter's storms are so intense that they make understanding the planet's atmosphere very difficult. Leah Crane tells us how the James Webb Space Telescope has revealed stark details in what were once blurry hazes, allowing astronomers to track the movement of chaotic features around Jupiter.

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Podcast

“Roosters are potentially able to recognise their own reflection as themselves”



Essential guide

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How's your health?

Focusing on health with as much precision as disease will make us all feel better

DO YOU feel healthy? Regardless of your answer, what are your reasons for your response? Did you say no because you are carrying some extra weight, feeling weak or have had more colds than anyone else this year? Or did you say yes because your blood pressure is good and you walk 10,000 steps a day? Maybe you said yes because you feel happy, in spite of any health conditions you may be experiencing.

The truth is that we often talk about improving our health, but figuring out what it actually means to be healthy is surprisingly difficult, as we discover in our cover feature on page 32. There is a straightforward reason. For decades, our medical institutions have focused on the question of “how do we treat

disease?” rather than asking “how do we promote and maintain health?”

This is down, in part, to a psychological bias we all share: we like to solve our problems by adding something, rather than taking something away. When it comes to health, it is no different. We feel

“Health isn’t a passive process, but an active state that should be studied and maintained”

ill, so we buy a test, get a prescription or take a pill. We don’t often consider what it is that we can stop doing to prevent ourselves from getting ill in the first place.

Things are changing though. Having begun to realise that some of our classic assessments of health, such as body

mass index, are flawed, attention is turning to which physiological processes might offer us the ultimate insight into what it means to be physically and mentally well.

This is leading to new tests that we can take today to give us a better idea of our current – and future – state of health. That researchers are increasingly seeing health not as a passive process, simply a happy consequence of an absence of disease, but as an active state that can and should be studied and maintained in its own right, is an encouraging shift in mindset. Applying the precision we level at diseases and their treatment to the phenomenon of “health-care” will no doubt help us all turn to “disease-care” a little less often. ■

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NewScientist

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Artificial Intelligence and the next computing revolution

Saturday 25 November 2023, 10am - 5pm
Cavendish Conference Centre, London

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**Talk topics
include:**

- How AI sees the world
- How ChatGPT works
- Maths of AI
- AI and creativity
- The ethics of AI
- AI and society

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Beatles revival
How AI brought John
Lennon back to life
for one last song **p9**

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Certain brain
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Hidden landscape
The ancient valleys
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Mirror test
Roosters may be
able to recognise
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Space

JWST shows Crab
Nebula in new light

The James Webb Telescope (JWST) has captured the Crab Nebula, a supernova remnant located 6500 light years away in the constellation Taurus. The smoke-like wisps are a product of the nebula’s pulsar, a rapidly rotating neutron star, generating magnetic fields that make particles emit electromagnetic radiation, which JWST can spot with its infrared camera.



NASA, ESA, CSA, STSCI, T. TEMIM (PRINCETON UNIVERSITY)

Climate change

We must hit net zero by 2034 to avoid breaching 1.5°C limit

Michael Le Page

FOR a 50/50 chance of global warming staying below 1.5°C, we can only emit around another 220 gigatonnes of carbon dioxide, according to the latest estimate. As we pump some 40 gigatonnes of the gas into the air each year, a figure that is still rising, we are on course to exceed this by 2029 or earlier.

As a result, keeping that 1.5°C goal alive now requires us to hit net zero globally by 2034 rather than by 2050, says Joeri Rogelj at Imperial College London. “There are no social or technical scenarios in the scientific literature that even describe how that would be possible.”

However, it is still feasible to limit warming to well below 2°C, says Robin Lamboll, who is also at Imperial College. To have a similar chance of keeping warming to 2°C, the world mustn’t emit more than 1200 gigatonnes of CO₂ (GtCO₂). This wouldn’t be exceeded until 2046 if emissions continue on their current track.

How much the planet warms depends largely on the amount of CO₂ in the atmosphere, and

“There are no social or technical scenarios that describe how achieving this would be possible”

that depends on how much more of it we emit. Based on this, climate scientists can calculate a carbon budget – the amount of CO₂ we can still pump out before warming passes a certain level.

Back in 2020, the Intergovernmental Panel on Climate Change (IPCC) estimated that the budget for a 50/50 chance of staying below 1.5°C of warming was about 500 GtCO₂. Now, a team that



VALENTIN FLAURAUD/EPFL-EFE/SHUTTERSTOCK

includes many of those behind the IPCC estimate has updated the work (*Nature Climate Change*, doi.org/k3d9).

The team calculated that the remaining budget, as of January, was around 250 GtCO₂. Since then, there have been another nine months of emissions, so the remaining budget will already be down to roughly 220 GtCO₂.

One of the main reasons for the reduction from 500 to 250 GtCO₂ is simply that there have been another three years of emissions since 2020. Most of the rest is due to better estimates of the effects of aerosol pollutants.

These pollutants, such as sulphur dioxide from the burning of fossil fuels, form tiny droplets in the atmosphere that have a cooling effect by reflecting sunlight and altering cloud brightness. There has been a lot of uncertainty about the magnitude of the cooling.

Now, the uncertainties have been narrowed down to the higher side of the range. If aerosol cooling is on the

Climate messages from children on a Swiss mountain

higher side, there will be more warming as fossil fuels are phased out and aerosol pollution falls. That means less CO₂ can be emitted if we are to limit temperature rise to a certain level.

“If Lamboll and colleagues are correct, mid-century net-zero targets are insufficient to prevent an overshoot of 1.5°C,” writes Benjamin Sanderson at the Centre for International Climate Research in Norway in a commentary that accompanied the research.

The study team doesn’t expect us to officially pass the 1.5°C threshold until some years after we exceed the budget, says team member Chris Smith at the International Institute for Applied Systems Analysis in Austria. Even so, there are gains to be made. “We still need to fight for every tenth of a degree. If we are able to limit warming to 1.6 or 1.65 or 1.7°C, that’s a lot better than 2°C,” he says. ■

Zoology

Insects disguise themselves as enemy spiders

Christa Lesté-Lasserre

SOME moths and flies can look like the jumping spiders that eat them – and the trick is highly convincing when viewed from a predator’s perspective.

This might allow such prey to escape before the spiders can recognise the ploy and pounce, says Dinesh Rao at the University of Veracruz in Mexico. “They just need a little bit more time, a little bit of confusion on the part of the predator, and that’s enough for them to move to a different part of the tree or leaf,” he says.

To better understand this type of mimicry, Rao and his colleagues collected more than 1000 photos of insects and spiders uploaded to iNaturalist and other citizen science platforms. Then they trained an artificial intelligence to distinguish images of jumping spiders from those of a range of insects.

The researchers then gave the AI a new set of images of various insects and asked it to evaluate the likelihood that the creatures pictured were jumping spiders.

Due to patterns on their bodies, the AI judged the Mediterranean fruit fly (*Ceratitis capitata*), arched marble moth (*Olethreutes arcuella*) and a barklouse (*Cymatopsocus enderleini*) to be jumping spiders



ANIDA ARIPIN/GETTY IMAGES

Thanks to their markings, some moths may look very much like a spider

with more than 90 per cent confidence (*Behavioural Processes*, doi.org/k3ds).

The angle of the photo turned out to be critical, however. “The angle where the mimicry is most apparent is where the predator is mostly coming from,” says Rao. ■

We may have seen a black hole's birth

Strange light undulations from a supernova blast could be evidence of a black hole's creation

Alex Wilkins

WE MAY have witnessed a black hole being born from a dying star, according to an analysis of an unusual rhythmic supernova.

When a star runs out of the fuel it needs for nuclear fusion, it goes supernova and collapses in on itself, falling onto the core and blasting out material in a bright explosion.

Astronomers have evidence linking extremely massive supernovae to the formation of ultra-dense remnants like neutron stars and black holes, collectively called compact objects, but this is from long after the star has exploded. A star has never been caught in the act of going supernova and birthing a dense descendant.

Now, Thomas Moore at Queen's University Belfast, UK, and his colleagues think they may have glimpsed evidence of a neutron star or black hole being born from a supernova, called SN 2022jli, because it has strange undulations in the light it gives off. "We've never seen anything

quite like this," says Moore.

Unlike normal supernova explosions, which tend to fade once they reach their peak after about a month, SN 2022jli faded before growing bright again, at 1 per cent of its maximum brightness. This continued in a pattern of periodic brightening and fading around every 12 days for more than six months, which hasn't been seen in any other supernovae.

SN 2022jli, which looks to have come from a massive star collapsing while in orbit around another star, has other unusual properties too. These include an extremely bright first peak to the explosion, and spectroscopic measurements of it show strong light from elements that don't fit with the normal timeline of such supernovae, says Moore.

This evidence suggests that the supernova either had an unusual parent, such as an extremely stripped-back star called a Wolf-Rayet star, or has given birth to a compact object, which is making

the supernova appear unusual, says Moore. However, his team doesn't have enough evidence to make a conclusion either way (*The Astrophysical Journal Letters*, doi.org/k23h).

Another group – Ping Chen at the Weizmann Institute of Science

Artist's illustration of a black hole born from a supernova



CHRISTOPHER BURSTED/SCIENCE PHOTO LIBRARY/ALAMY

in Israel and his colleagues – has separately observed SN 2022jli and has detected emissions of hydrogen late in the supernova's lifetime. These researchers think the emissions come from the remaining star in the pair having material sucked away and then ejected by the neutron star or black hole. They also detected gamma rays from the direction of the supernova, which could be from the compact object too (arXiv, doi.org/k23j).

While astronomers are fairly sure that supernovae form compact objects, understanding what kind of star went supernova and how it happened could give us crucial information on how black holes and neutron stars are born, says Justyn Maund at the University of Sheffield, UK.

The combination of observations suggests that we really are witnessing the birth of a compact object, he says. "They've tried to make this complete picture, which I think is very convincing." ■

Technology

AI brings John Lennon's vocals to new Beatles' song

THE Beatles have released what is said to be their last ever song, pieced together from recordings spanning more than four decades, in a feat that was possible due to artificial intelligence.

On 2 November, the iconic band released *Now and Then*, a song edited from a recording of the late John Lennon playing piano and singing at home in 1979. AI was used to extract usable sections from that noisy tape.

These were combined with

guitar tracks from the late George Harrison, recorded in 1995 when efforts were made to finish the song. Reportedly, the endeavour was initially called off due to poor sound quality, an issue solved by AI.

Finally, new recordings made earlier this year by Paul McCartney and Ringo Starr were added. The single bookends the band's career by also including *Love Me Do*, their first single, as a B-side.

McCartney has teased the song in interviews for months and said in a statement: "There it was, John's voice, crystal clear. It's quite emotional. And we all play on it, it's a genuine Beatles recording."

Film director Peter Jackson's

production company WingNut Films is credited for "source separation". The firm also made the documentary *Get Back*, featuring footage of The Beatles recording *Let it Be*.

When creating *Now and Then*, engineers at WingNut worked on 60 hours of recording captured by a single microphone that picked up the musicians' instruments in a noisy jumble. The microphone also caught background chatter, making much of the recording unusable.

The team used AI to separate

"There it was, John's voice, crystal clear. And we all play on it, it's a genuine Beatles recording"

the dialogue from other noises, also isolating the sound of each instrument being played.

Jess Aslan at Goldsmiths, University of London, says The Beatles' track was done with the blessing of the living members of the band, but adds that AI also presents risks to artists.

"One significant issue is that generative AI is squeezing the already extremely narrow creative job market," she says. "Another is that of ownership, in that these large-scale models are in effect bypassing copyright laws and reconfiguring artists' data without consent." ■

Matthew Sparkes

Is it really vital to get 8 hours of sleep a night? The largest analysis of brain scanning data yet casts doubt on the idea that shorter sleep duration is linked to shrinkage of the brain, reports **Clare Wilson**

EVERYONE knows that going to bed too late can leave you less alert the next day. But recent claims have gone further, promoting the idea that regularly getting too little sleep raises the risk of Alzheimer's disease and even shrinks the brain.

Now, this idea has been challenged by one of the most comprehensive analyses of brain scanning studies to date. So how much do we really need to worry about getting enough shut-eye?

Most health bodies, such as those in the US and the UK, advise that adults generally need between 7 and 9 hours of sleep a night. And, thanks to wrist-worn sleep tracking devices, it has never been easier to know if you are meeting this quota.

It is understandable that some people obsess over getting enough sleep. Widely covered animal research shows that the brain's cleaning system ramps up at night, ridding it of toxic compounds linked to Alzheimer's disease, such as a protein called beta-amyloid. And large population studies have generally found that people with unusually short or long sleep durations have worse health by several measures, including memory loss and brain shrinkage, one of the hallmarks of Alzheimer's.

Typically, there is a roughly U-shaped curve for the relationship between hours of slumber and the chances of a bad health outcome, such as dementia, and an inverted U-shaped curve for measures where a higher value signifies better health, such as brain volume seen on an MRI scan.

But such population studies can only find correlations between sleep duration and health. They can't tell us if poor sleep is causing the health condition. Only a randomised trial could do that, but these are almost impossible to set up in this case, because few people would agree to change their sleeping habits for



FIORDALISO/GETTY IMAGES

any length of time in the name of science, says Anders Fjell at the University of Oslo in Norway.

Fjell and his team have now tried to take a deeper look through a series of studies that used brain volume as a proxy for brain health (*Nature Human Behaviour*, doi.org/k3df). First, they investigated brain volume in relation to sleep duration at a single point in time, using existing data on about 47,000 people. Here, they found an inverted U-shaped curve, although the

6.5 hours

Sleep duration linked to maximum brain volume in a new analysis

highest brain volume was linked with a surprisingly low 6.5 hours of sleep per night.

The team then carried out a further analysis on data that tracked about 4,000 people for up to 11 years. In this case, there was no correlation between sleep duration at the beginning of the study and brain shrinkage over this period. "It would be very surprising to see this, if short sleep had a negative effect on the brain," says Fjell.

The correlation seen in the first

When we sleep, the brain clears out waste substances

analysis could be explained by brain shrinkage causing sleep disturbance, rather than the other way around. Alternatively, it could just reflect stable differences between people, rather than the results of brain shrinkage, such as that people with naturally smaller or larger brains tend to sleep less for some unknown reason, he says.

The researchers also did a third kind of analysis of about 30,000 people, using genetic data gathered from the same sources as their first study. This found that those who are genetically predisposed to have either short or long sleep durations don't have smaller brain volumes than more moderate sleepers. Put together, this set of results challenges the idea that failing to get enough sleep shrinks the brain, says Fjell.

While he doesn't advise anyone to deliberately change their sleeping habits as a result of the findings, Fjell believes that there is much natural variation in people's innate sleep requirements and – unless prevented by circumstances – a person's brain will make sure it

gets the necessary amount.

"If you are feeling tired all day, then you probably sleep too little, and that can have negative consequences," he says. "But as long as you feel fine during the day, I wouldn't worry about whether your sleep is 6, 7 or 8 hours."

It is unlikely that the team's conclusions will convince everyone. Matthew Walker at the University of California, Berkeley, who wrote a book called *Why We Sleep* – which advises people to sleep for 8 hours a night – says the key measure of brain health is neuron density, rather than total brain volume. "Those two measures are not perfectly correlated with each other, which tells us that they measure different things," he says.

Walker also says the crucial measure of sleep quality is how long people spend in deep sleep – when brainwaves become slower – rather than their total quantity of sleep.

Certainly, it is during this slow-wave sleep that amyloid clearance from the brain intensifies. However, most such sleep happens during the first 4 hours of the night, says Fjell. "It is unclear whether more sleep than that would further facilitate this clearance," he says.

Maiken Nedergaard at the University of Rochester in New York says this is an important piece of work, due to its finding that, in the single-time-point analysis, larger brain volume was linked with a mere 6.5 hours of sleep a night. "The surprise is that the optimal sleep duration is shorter than what is currently recommended," she says.

This result suggests, therefore, that even if you are concerned about total sleep duration, you may not need to worry about falling short of 8 hours a night. "You should not lie in bed tossing and turning to meet [that] target," says Michael Chee at the National University of Singapore. "This study is quite reassuring." ■

Biology

Trip to space and back has no effect on mouse embryos

Alice Klein

MOUSE embryos have been cultured on the International Space Station (ISS) for the first time, in an effort to explore whether it might be safe for humans to become pregnant in space.

"There is a possibility of pregnancy during a future trip to Mars because it will take more than 6 months to travel there," says Teruhiko Wakayama at the University of Yamanashi in Japan, who led the study. "We are conducting research to ensure we will be able to safely have children if that time comes."

Wakayama and his colleagues performed the first steps of the experiment in their lab on Earth, extracting embryos that were at an early two-cell stage from pregnant mice and freezing them.

The frozen embryos were sent to the ISS on a SpaceX rocket that launched from Florida in August 2021. Astronauts on the station thawed the embryos and cultured them for four days, which is how long they can survive outside a uterus. The astronauts then chemically preserved the embryos and sent them back to Earth on a return vessel.

Wakayama's team studied the returned embryos to see if they had been affected by their exposure to the higher radiation and low gravity in space. The embryos didn't show signs of DNA damage from the radiation exposure, possibly because they were only in space for a short time (*iScience*, doi.org/k234).

They also displayed normal structural development, including differentiation into two groups of cells that form the basis of the fetus and placenta. This was an important finding because it was previously thought that microgravity may affect the ability of embryos to separate into these two different groups of cells, says Wakayama. ■

Zoology

Starfish are actually flattened heads with no bodies

Claire Ainsworth

SCIENTISTS trying to work out where a starfish's head is have come to a startling conclusion: it is effectively the whole animal. As well as solving this long-standing mystery, the finding will help us understand how evolution generates the dramatic diversity of animal forms on Earth.

Starfish, also known as sea stars, belong to a group of animals called echinoderms, which includes sea urchins and sea cucumbers. Their strange body plans have long puzzled biologists. Most animals, including humans, have a distinct head end and tail end, with a line of symmetry running down the middle of their body, dividing it into two mirror-image halves. Animals with this two-sided symmetry are called bilaterians.

Echinoderms, on the other hand, have five lines of symmetry radiating

from a central point and no physically obvious head or tail. Yet they are closely related to animals like us and evolved from a bilaterian ancestor. Even their larvae are bilaterally symmetrical, later radically reorganising their bodies as they metamorphose into adults.

"The body of an echinoderm is essentially a head walking about the seafloor on its lips"

These profound differences make it hard for scientists to find and compare equivalent body parts in bilaterians to work out how echinoderms evolved. "The morphology cannot tell you anything, almost," says Laurent Formery at Stanford University in California. "It is just too weird."

Formery and his colleagues decided to look at a set of genes known to direct the head-to-tail organisation of all bilaterians. In these animals, the genes are turned on, or expressed, in stripes in the outer layer

of the developing embryo. The genes that are expressed in each stripe define which point on the head-to-tail axis it will become.

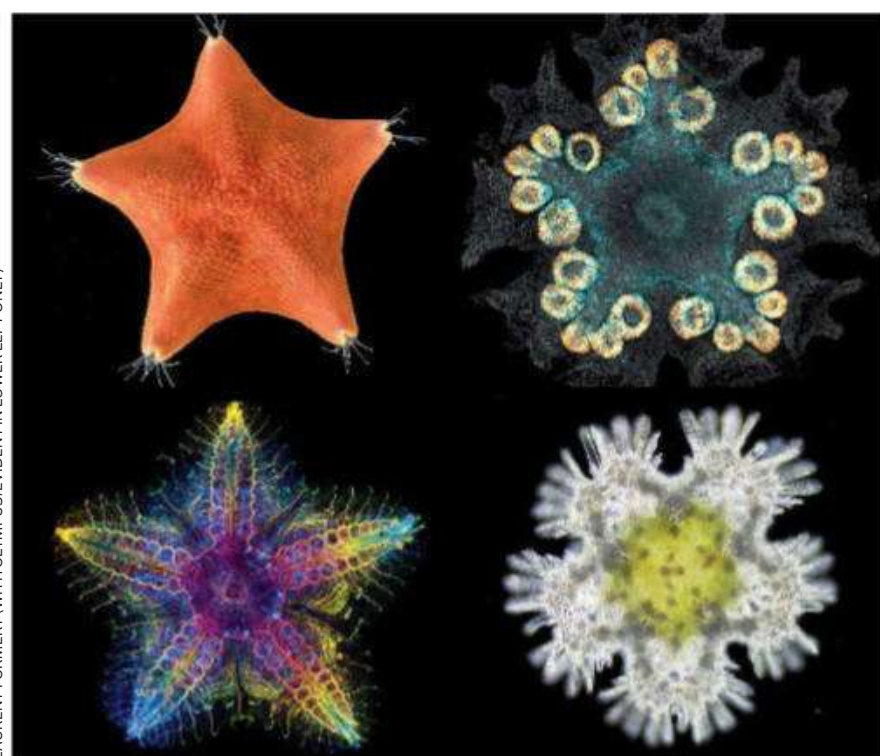
The idea was to see if the gene expression patterns would reveal a "molecular anatomy" hidden in echinoderms. "This particular suite of genes is just good for exploring animal diversity in its most extreme forms," says team leader Chris Lowe, also at Stanford University. "I think echinoderms represent a really extreme experiment in how to use that bilateral network to produce a very, very different body plan."

To the team's surprise, the genes that determine the head end in bilaterians were expressed in a line running down the middle of each arm on the underside of a starfish. The next "head-most" genes were expressed on either side of this line, and so on (*Nature*, DOI: 10.1038/s41586-023-06669-2).

Even more strangely, the genes normally expressed in the trunk of bilaterians were missing in the outer layer of the animal. This suggests that starfish have jettisoned their trunk regions and freed up the outer layer to evolve in new directions, says Formery.

The findings show that "the body of an echinoderm, at least in terms of the external body surface, is essentially a head walking about the seafloor on its lips", says Thurston Lacalli at the University of Victoria in Canada. Animals like us may have kept their trunks to escape predation by swimming away. "Echinoderms hunkered down and armoured themselves, so they didn't need a trunk," says Lacalli. ■

Fluorescent stains labelling various tissues in a starfish



LAURENT FORMERY (WITH OLYMPUS/EVIDENT IN LOWER LEFT ONLY)

Do other animals have a menopause?

Female humans and whales have a post-reproductive life stage, but what about other mammals? It depends how you ask the question, says **Michael Le Page**

ONLY humans and a few toothed whales undergo the menopause, many sources will tell you. But a paper by Ivana Winkler and Angela Goncalves at the German Cancer Research Center claims that the menopause is, in fact, widespread among mammals. So which is right? The surprising answer is both.

Goncalves studies how the female reproductive tract ages in mice. “It’s absolutely clear that our mice in captivity reach something that is like menopause in humans,” she says. “And yet every time that I present this work to an audience, I get the question, ‘but I thought only humans had a menopause?’”

So Goncalves and Winkler set out to establish which other mammals have a menopause by reviewing published studies.

The first issue is that most other mammals don’t menstruate in the sense of bleeding when the lining of the uterus is shed. Instead, the lining of the uterus is reabsorbed.

If you define the menopause in the narrow sense of the ending of menstruation, most mammals cannot undergo it because they don’t menstruate to begin with. However, biologists generally use the term in a wider sense. “The term is used in the literature to mean cessation of reproduction, and does not depend on menstruation,” says Simon Chapman at the University of Turku in Finland.

The key physical thing that results from the menopause is the ovaries stop releasing eggs – the oopause. But finding out if and when most mammals undergo oopause is far from easy.

In some species, the presence or absence of reproductive cycles can be directly established by, for instance, looking at hormone levels in blood. But scientists



HELMUT CORNELI/ALAMY

can usually only do such studies in captive animals. For most species, researchers have to infer the timing of the oopause from when individuals cease reproducing, which is also typically gleaned from animals living in captivity.

In their analysis, Winkler and Goncalves looked at studies that included at least 10 captive individuals. While they found reliable studies for less than 100 species, the results showed

“If you’re kept safe from the dangers of the world, eventually you’ll run out of eggs”

that the vast majority of these mammals stopped producing eggs if they lived long enough. Female mammals typically underwent the oopause when they were between one-third and two-thirds of the way through their maximum possible lifespan (*Cell*, doi.org/k233).

“This shows that the [female] reproductive system stops working much earlier than the rest of the body,” says Goncalves.

Sperm whales are widely considered to undergo menopause

“And for me, it’s absolutely relevant that this happens in other species as well.” Previous studies have suggested this is the case, says Goncalves, but theirs is the most comprehensive and rigorous analysis so far.

If the menopause is defined as animals undergoing an oopause when they live to a relatively old age rather than being killed by predators or disease, then the pair’s study provides good evidence that the menopause is common in many mammals. But Goncalves isn’t claiming that most wild females survive long enough to undergo the oopause. “It’s not about what’s happening in the wild,” she says.

“This paper shows nicely that if you’re kept safe from the dangers of the world, eventually you’ll run out of eggs,” says Sam Ellis at the University of Exeter in the UK.

In 2017, his team showed that, in the wild, females from a few species of toothed whale regularly live for significant periods after

they are unable to reproduce. His study is the main source for the claim that the menopause occurs only in humans and a handful of whales. But Ellis agrees it depends on which definition you use.

“I deliberately focused on wild populations, and they’ve deliberately focused on captive populations,” he says. “I think both are equally valid. It depends on the kind of question you’re trying to ask.”

Chimp findings

Coincidentally, a separate study published the same day by Brian Wood at the University of California, Los Angeles, and his colleagues described the first evidence for the menopause in wild chimpanzees. There have been occasional reports of individual chimps surviving well past the age they can reproduce. But in one group in Kibale National Park in Uganda that has been studied for more than 20 years, more than a third of females have been surviving past this point (*Science*, doi.org/gsx9jw).

However, this particular group has managed to expand its territory – meaning it has plenty of food – in a region where human hunters have wiped out predators such as leopards. So the observation may be a temporary result of unusually favourable circumstances, rather than the norm, the researchers say. If so, it fits in neatly with both Goncalves’s and Ellis’s findings.

It is clear that female animals in the majority of mammal species stop producing eggs long before the end of their maximum potential lifespans, but few reach this point in the wild. Whether this means the menopause is common or rare comes down to how you define it. ■

Physics

The Great Sphinx may have been largely blown into shape by the wind

Karmela Padavic-Callaghan

FLOWING water can carve majestic lions out of rocks or clay – and it is possible a similar natural process gave a rocky outcrop in Egypt a lion-like shape that was further modified by the ancient Egyptians to create the Great Sphinx of Giza.

Writing in *Smithsonian Magazine* in 1981, geologist Farouk El-Baz conjectured that “Desert Builders Knew a Good Thing When They Saw It”. He suggested sculptors took advantage of a naturally occurring landform to create the Great Sphinx.

Now, Leif Ristroph at New York University and his colleagues have produced evidence that may favour the idea. They saw miniature versions of lion-like landforms emerge from lumps of clay immersed in flowing water. Their tiny, water-carved “mud lions” point towards a mechanism by which wind could sculpt similar shapes out of desert rocks.

To study how clay erodes when water runs over it, they fashioned oval-shaped mounds out of bentonite clay, embedding a small chunk of hard, non-erodible plastic at one end of each one.

They then placed each lump in a water tunnel and allowed the liquid to flow over it parallel to its long axis, with the plastic at the “upstream” end of the tunnel. Lion-like shapes appeared as the water carried away the soft, erodible clay while leaving the plastic cylinder behind.

“We were struck by the resemblance to a seated lion or a lion in repose,” says Ristroph.

The Great Sphinx may have been partially formed by wind (inset)



SHUTTERSTOCK/ALEXANTON; INSET: AML/COURANT INSTITUTE/INYU

“And I was reading about this and came across the idea that perhaps even the Great Sphinx was one of these natural formations that then got, obviously, a little facelift from the ancient Egyptians.”

Across several experiments, the plastic provided a template for the “head” of the small mud lion. The flow of water around it carved its curved back, thin neck and broad paws “for free”. The findings will be published in *Physical Review Fluids*.

“The fluid is eating away the solid, but the solid then forces

the flow to conform to its shape. It feeds back on the flow and changes erosion rates and how it is distributed over the surface,” says Ristroph. This exchange between the flow and the shape it is carving makes simulating or modelling the process difficult, so practical experiments are very informative, he says.

The microscopic mechanisms by which wind erodes rock are rather different from how water erodes clay. But Jani Radebaugh at Brigham Young University in Utah says the geological phenomenon seen in the lab is called a yardang. These formations exist across the world’s deserts. She believes that, in the desert, yardangs could arise from fairly even rocks if there is enough variation in the wind flow. They even exist on Mars, she says, as the lack of water has allowed erosion to create many Sphinx-like yardangs there too.

Ristroph and his colleagues are now working on developing a mathematical description of this process and understanding how it might scale from clumps of clay to Sphinx-sized rocks. ■

Technology

Als can guess where you live and how much you earn

LARGE language models (LLMs) like GPT-4 can identify a person’s age, location, gender and income with up to 85 per cent accuracy simply by analysing their posts on social media.

Robin Staab and Mark Vero at ETH Zurich in Switzerland got nine LLMs to pore through a database of Reddit posts and pick up identifying information in the way users wrote.

Staab and Vero randomly selected

1500 profiles of users who engaged on the platform, then narrowed these down to 520 users for which they could confidently identify attributes like a person’s place of birth, their income bracket, gender and location, either in their profiles or posts.

When given the posting history of those users, some of the LLMs were able to identify many of these attributes with a high degree of accuracy. GPT-4 achieved the highest overall accuracy with 85 per cent, while LLaMA-2-7b, a comparatively low-powered LLM, was the least accurate model with

51 per cent ([arXiv, doi.org/gswc6r](https://arxiv.org/abs/2310.12050)).

“It tells us that we give a lot of our personal information away on the internet without thinking about it,” says Staab. “Many people would not assume that you can directly infer their age or their location from how they write, but LLMs are quite capable.”

Sometimes, personal details were explicitly stated in the posts. For example, some users post their

“We’re only just beginning to understand how privacy might be affected by use of large language models”

income in forums about financial advice. But the Als also picked up on subtler cues, like location-specific slang, and could estimate a salary range from a user’s profession and location.

Some characteristics were easier for the Als to discern than others. GPT-4 was 97.8 per cent accurate at guessing gender, but only 62.5 per cent accurate on income.

“We’re only just beginning to understand how privacy might be affected by use of LLMs,” says Alan Woodward, at the University of Surrey, UK. ■

Chris Stokel-Walker

The health costs of wildfires

Wildfires have undone years of progress on improving air quality, and the smoke can have devastating effects on our bodies, reports **Grace Wade**

AFTER months of devastating fires, Canada's worst wildfire season worsened even further in September. In just seven days, blazes across the country burned through as much land as is usually scorched in an entire fire season. The smoke stretched over Greenland and northern Europe, bringing with it toxic particles that can lead to everything from asthma to heart attacks.

This story is increasingly common. Canadian wildfires earlier in the year sent smoke south that blanketed much of the eastern and central US, choking the sky and prompting warnings of dangerous air quality. Meanwhile, an extreme heatwave in July and August fuelled flames along the Mediterranean, including the largest blaze ever recorded in the European Union.

The increase in both the frequency and severity of wildfires in recent years, and the resulting smoke plumes, have undone years of progress. "For a long time, wildfires have been a pretty small component of overall air quality," says Marshall Burke at Stanford University in California. "That has started to change."

For human health, pollution particles less than 2.5 micrometres in diameter – known as PM2.5 – are most concerning. These particles constitute up to 90 per cent of wildfire smoke (see "What is in wildfire smoke?"). "When you inhale PM2.5, the particles are so small that they can actually cross over at the base of the lungs into the bloodstream," says Mary Johnson at Harvard University. She says this leads to respiratory and neurological issues.

Over the past two decades, countries across the globe have worked to reduce levels of PM2.5, mainly from industrial sources. The US began regulating the



DAVID DEDELGADO/GETTY IMAGES

pollutant under the Clean Air Act in 1997. Canada set its first targets for PM2.5 in 2000, and the European Union did so in 2005. As a result of these efforts, global PM2.5 exposure fell by nearly 11 per cent between 2011 and 2019.

Wildfire smoke now jeopardises these improvements. Using ground and satellite-based air pollution data, Burke and his colleagues analysed the contribution of wildfire smoke

to PM2.5 levels in the US between 2000 and 2022. They found that average annual PM2.5 concentrations declined in nearly every state from 2000 to 2016. Then, the downward trend started to significantly slow or begin ticking upwards. "We find that, absent wildfires, concentrations of PM2.5 would have continued to decline around the country. Instead, we see those declines flatten and, on the west coast, start to reverse," he says.

Wildfire smoke influenced PM2.5 levels in nearly three-quarters of states in the contiguous US, eroding about 25 per cent of the progress on air quality made since 2000. In western states, wildfires negated more than half of such progress (*Nature*, doi.org/gssbqn).

Wildfires are common in the western US and have only grown fiercer over the past decade. Some of the region's most destructive fires occurred between 2015 and 2020, and megafires in 2020

Orange skies over New York caused by fires in Canada

resulted in the country's worst fire season on record.

The team estimates that, without interventions, wildfires' contribution to air quality trends in the US will continue to grow as the climate warms. Projections show that in the western US, an average annual 1°C increase in temperature could increase the amount of land wildfires burn by as much as 600 per cent.

A global phenomenon

The US isn't alone in this trend. Beginning in 2017, PM2.5 levels during the summer in British Columbia skyrocketed. For instance, peak concentrations in 2020 were nearly three times as high as those between 2010 and 2016, and the province saw annual fine particulate levels rise by about 50 per cent between 2005 and

200%
Increase in summer PM2.5 levels
in British Columbia, Canada

33,500
Number of people who die yearly
due to wildfire-related PM2.5

41%
Covid-19 deaths in Butte county,
California, in 2020 due to wildfires



2018. In south-east Australia, wildfires accounted for more than 70 per cent of PM2.5 between December 2019 and January 2020, when unprecedented bushfires scorched the country. The fires increased annual exposure to

critical for fighting off disease, she says. For example, one study attributed 41 per cent of covid-19 deaths and 17 per cent of covid-19 cases in 2020 in Butte county, California – a region hard hit by fire that year – to wildfire exposure.

Pregnant people and children appear to be most at risk. Studies have shown that consistent, long-term PM2.5 exposure during pregnancy raises the likelihood of preterm birth and fetal death, as well as neurological and cognitive problems in children. Long-term exposure during childhood has also been linked to impairments in lung function and higher rates of asthma, chronic bronchitis and obesity.

But PM2.5 exposure from wildfire smoke is unique, and few studies have investigated the effects of short, repeated bouts of high PM2.5 from wildfires. “We definitely know there are health complications with chronic exposure, but we don’t have a good grasp on [what happens to] healthy people if they are exposed to one wildfire, say, every three years,” says Johnson.

What is in wildfire smoke?

In addition to fine particulate matter, wildfire smoke contains many pollutants that can also harm health.

Heavy metals in soil and infrastructure, such as lead, aluminium and copper, are picked up and dispersed by fire. When inhaled, these can cause lasting damage to the lungs and nervous system.

Carbon monoxide can linger in the atmosphere for a month and travel great distances. It prevents oxygen from reaching organs, leading to headaches,



Planes drop water on a wildfire in British Columbia in July 2023

“We didn’t have to ask this question before, but now [people] are likely to get hit again and again by smoke,” says Brauer. “What does that do for your overall lifespan?”

Fight fire with fire

Humans have suppressed fires for centuries, which leaves fuel just waiting to burn, says Burke. Prescribed burns – small, low-intensity fires purposefully ignited to clear underbrush –

can reduce the frequency and intensity of wildfires, says Alfredo Gómez at the US Government Accountability Office (GAO) in Washington DC. “If you do that, you don’t generate that much smoke and you reduce the likelihood of extreme fires in the future,” says Burke.

However, in the US, smoke from prescribed burns is regulated under the Clean Air Act, and counties are fined if these burns elevate PM2.5. But the air pollution from wildfires doesn’t trigger the same fines. Gómez says this disincentivises proper land management techniques. Earlier this year, he and his colleagues at the GAO recommended the US government change air pollution laws to exempt prescribed burns.

This may have to be combined with efforts to protect indoor air quality, as people spend more time inside during the worst air quality days. “We’ve looked at indoor air quality during wildfire events, and it is really bad,” says Burke. Even shutting windows and doors doesn’t keep out wildfire pollutants, he says.

One solution is air filters, which remove particulate matter. Providing at-home filtration devices for free or at a reduced cost would be an effective solution, says Brauer. Law-makers could also amend air pollution laws to include indoor air quality, which would incentivise schools, businesses, workplaces and landlords to install air filtration devices, says Burke.

“We need to think more about protection. How do we, basically, live with it? That’s a really different approach than we’ve previously had for air quality,” says Brauer. ■

“People are likely to get hit again and again by smoke. What does that do for your overall lifespan?”

PM2.5 in most of the nation during those years, reversing improvements in 2017 and 2018.

“It is going to get worse because this isn’t just one place. It’s a global phenomenon,” says Michael Brauer at the University of British Columbia in Canada.

Inhaling all this particulate matter is hard on the body. In a separate study, Burke and his team estimated that wildfire smoke in California led to an additional 3000 emergency department visits per year between 2006 and 2017. They also found that in each week following a day of extreme smoke, visits for asthma, cough and chronic obstructive pulmonary disease (COPD) increased by 30 to 110 per cent.

A large body of evidence indicates that even a few hours of exposure to elevated PM2.5 can trigger heart attacks and death. An estimated 33,500 people die each year from exposure to wildfire-related PM2.5 worldwide. During Australia’s devastating bushfire season in October 2019 to January 2020, deaths from short-term PM2.5 exposure increased by 38 per cent compared with a scenario where no fires occurred.

Exposure to wildfire smoke also impairs the immune system, leaving people vulnerable to pathogens, including covid-19, says Johnson. This could be due to smoke depleting immune cells

Technology

Record-breaking quantum computer has over 1000 qubits

Alex Wilkins

THE world's first quantum computer to exceed 1000 qubits has more than double the number of the previous record holder, IBM's Osprey machine, which has 433 qubits. Although having more qubits doesn't necessarily mean better performance, large numbers of them will be needed for future error-free quantum computers that are useful, unlike today's noise-filled research machines.

The largest quantum computers, such as those from IBM and Google, use superconducting wires cooled to extremely low temperatures for their quantum bits, or qubits. But the record-breaking machine from California-based firm Atom Computing, which has 1180 qubits, instead uses neutral atoms trapped by lasers in a two-dimensional grid.

One advantage of this design is that it is easy to scale up the system and add many more qubits into the grid, says Rob Hays, CEO of Atom Computing. Any useful quantum computer in the future that is free of error will need at least tens of thousands of dedicated error-correcting qubits working alongside the programmable qubits, he says.

"If we're only going to scale by dozens of qubits, like most of the trapped ion and superconducting systems have been scaling up until now, it's going to take a very long time to get to the fault tolerant era," says Hays. "With the neutral atom approach and the speed of scaling that we have, we will be able to get there much more quickly." He says the team aims to multiply the amount of qubits in the machine by around 10 every few years.

Unlike conventional

computing bits, which can have a value of 1 or 0 and are largely interchangeable, qubits are more varied, having a range of different properties depending on how they are made.

Neutral atom qubits lend themselves better to quantum entanglement, a strange quantum effect where qubits are linked, so that measuring a property of one qubit reveals that of the other. They are also more stable, with qubits in Atom Computing's machine keeping their quantum state from collapsing – a feature called fault tolerance, which is essential for error correction – for almost a minute. IBM's Osprey, for example, has a so called coherence time of around 70 to 80 microseconds.

These long coherence times are due to the ytterbium atoms that Hays and his team use as qubits. Most neutral atom machines use an atom's electron as the quantum element with which to do computing, but this can be easily affected by the powerful lasers used to hold it in place.

The largest quantum computer yet built, made by Atom Computing



ATOM COMPUTING

With ytterbium, a quantum property of the atom's nucleus called spin can be used, which is much less sensitive to disturbances. "The nucleus just doesn't interact with the outside environment as strongly as the electron does," says Ben Bloom at Atom Computing.

Because qubits can be so varied, it can be hard to compare quantum computers, but Bloom says Atom Computing's machine is comparable in processing ability to IBM's, although the company has yet to release figures on this.

"This is where the frontier of the field is now, with this 1000-plus scale that people are developing"

The team hopes to offer the machine to customers next year for cloud computing applications, similar to what companies like IBM do today. "Atom Computing's machine can't currently perform computing operations on all the qubits at the same time, which will be required for fully error corrected machines," says Bloom.

"There's multiple groups now building systems that will have 1000, and even several thousand, atomic qubits," says Mark Saffman at the University of Wisconsin-Madison. "This is really where the frontier of the field is now, with this 1000-plus scale that people are developing."

However, Atom Computing will need to release more details of how the machine works before it can be assessed, says Saffman, such as how many of the qubits can be used and have logical operations performed on them. ■

Neuroscience

We are homing in on brain cells that cause motion sickness

Grace Wade

CERTAIN neurons in mice appear to govern the animals' experience of motion sickness. If the same is true for humans, it could lead to new ways of treating the condition.

Motion sickness occurs when your eyes perceive movement differently than your vestibular system, which detects how your body moves through space and is made up of structures in your inner ear. When your brain receives conflicting information, as it can during a car or boat ride, you may feel queasy, dizzy or off-balance.

Now, Albert Quintana at the Autonomous University of Barcelona in Spain and his colleagues have examined brain cells in the vestibular system of mice, focusing on a set of neurons previously shown to play a role in balance.

Using a technique to switch cells on and off with light, the researchers activated these neurons in seven mice. They assessed whether the rodents ate less and moved around less, indicators of motion-sickness symptoms.

After half an hour, these mice travelled a third as far as five other mice that didn't have the neurons activated – a distance comparable to that travelled by mice who had been spun in a rotation device. The animals also ate less food after the cells were activated, which the authors say could be due to nausea.

The researchers then gave 10 mice a drug called devazepide to block a receptor in the cells known to play a role in nausea, before spinning them in a rotation device. Half an hour later, these animals walked three times the distance of mice that were given a placebo before being spun (PNAS, doi.org/k2zq).

This suggests that devazepide could be used to prevent motion sickness if the same brain pathway dictates motion sickness in humans, says Quintana. ■

Ancient valleys seen beneath ice

A hidden landscape has been unveiled under the East Antarctic ice sheet

James Dinneen

A LANDSCAPE shaped by rivers and glaciers over millions of years seems to have been preserved beneath the East Antarctic ice sheet. The finding suggests that this area of Antarctica may have been covered in ice for more than 30 million years.

Aside from a few mountain peaks, nearly all of the geological features of Antarctica are covered in a sheet of ice more than 2 kilometres thick. Radar measurements have revealed the broad contours of this hidden landscape, but the details remain largely obscure.

Now, Stewart Jamieson at Durham University in the UK and his colleagues have looked at satellite radar measurements of the surface of the East Antarctic ice sheet to get a new view. "Any ice sitting on the top is going to very generally undulate over those mountains or those hills," says Jamieson. They then checked the topography inferred from the ice surface against direct measurements from ice-penetrating radar recorded by aerial surveys.



ICECAP

Ice-penetrating radar was used to survey Antarctica from the air

Together, the radar measurements revealed a region dubbed Highland A, which was distinct from the surrounding landscape. The 32,000-square-kilometre area features three blocks of land, separated by wide, fjord-like troughs. If the ice were removed, the topography wouldn't be dissimilar to the peaks and valleys of the Lake District in the UK, says Jamieson.

The researchers posit that these features describe a geological history stretching back to the separation of Antarctica from the Gondwana supercontinent some 180 million years ago. They suggest the "fjords" between the blocks of land were shaped by rivers flowing through rifts created by the break-up, then carved out further by glaciers when the climate cooled around 34 million years ago (*Nature Communications*, doi.org/gsxfcg).

As cooling accelerated and the ice sheet grew above the region,

the topography in surrounding areas was scrubbed away. But Jamieson says the features of Highland A were preserved because the glaciers formed a cold base beneath the ice

34m

Number of million years Highland A may have been under ice

sheet that locked onto the rock and prevented erosion. "The glaciers switch from being an erosive mechanism to being a protective mechanism."

The preserved landscape also suggests that the region has been covered in ice for at least 14 million years, if not 34 million years, says Jamieson. "If you had a huge retreat [of the ice sheet], then our landscape would have got scrubbed away."

The findings could improve models of how the rarely studied East Antarctic ice sheet will respond as climate change raises average temperatures, says Mathieu Morlighem at Dartmouth University in New Hampshire. ■

Bird flu reaches the Antarctic and could cause devastation

ANTARCTICA'S remoteness has protected it from deadly bird flu in recent years, but that looks set to change. The lethal form that has been killing millions of wild birds around the world has reached the Antarctic region, where it is feared it will have a devastating impact.

"There are species on some of the Antarctic islands and sub-Antarctic islands that are unique to those islands, and only occur in small

numbers, in hundreds or thousands," says Thijs Kuiken at Erasmus University Rotterdam in the Netherlands. "If the virus reaches those populations, they are in threat of extinction."

The highly pathogenic form of H5N1 bird flu that has been killing many wild birds in Europe, Asia and Africa since 2020 was carried across the Atlantic to North America in 2021. In October 2022, it was detected in South America.

There it is known to have killed thousands of marine mammals and hundreds of thousands of birds of many species, and the true numbers



J LIVERPOOL/RADHARC IMAGES/ALAMY

Giant petrels are one of two species that seem to be dying of bird flu in the Antarctic region

are likely to be much higher. By December 2022, it had spread to the southern tip of South America.

Researchers at a British Antarctic Survey station on Bird Island, just off the larger island of South Georgia, have now found some sick brown skuas and giant petrels. Tests

have come back positive for bird flu.

So far, only 30 dead birds have been found, but the fear is that H5N1 could spread rapidly in the large and dense bird colonies on Bird Island and South Georgia.

Animals in the Antarctic haven't been exposed to highly pathogenic bird flu before, but "there is a real chance that the virus will reach, or has already reached, the mainland of Antarctica", says Kuiken. Birds such as penguins are slow breeders, he says, so it may take decades for populations to regrow if they are hit as badly as species elsewhere. ■

Michael Le Page

Health

Discovery of key gene variants could help treat migraines

Chen Ly

AN ANALYSIS of 1.3 million people's genomes has revealed dozens of variations associated with migraines, which could lead to more effective treatments.

It is thought that up to 20 per cent of adults get migraines, which are recurrent, often incapacitating, headaches that are hard to treat. Some people have sensory symptoms, such as flashing lights or tingling in the body, before the onset of a headache, while others don't. It isn't known why these two types of migraine – known as with or without aura – exist.

"Migraine is well known to run in families, but it has not been easy to identify a clear genetic basis for each subtype," says Debbie Hay at the University of Otago in New Zealand.

Now, Kári Stefánsson at deCODE Genetics, a company in Iceland, and his colleagues have identified dozens of genetic variations that seem to influence whether people develop migraines. The researchers analysed the DNA of 1.3 million people from Iceland, Denmark, the UK, the US and Norway, of whom about 80,000 got migraines.

They identified 44 gene variants associated with the condition, 12 of which have never been described before. Of these, the team discovered that a rare variant of the *PRRT2* gene, which helps regulate signalling between neurons, correlates with a large risk of migraine with aura, and epilepsy.

But they found that rare variants that suppress the function of the *SCN11A* and *KCNK5* genes, which play a role in transporting sodium and potassium between cells, respectively, appear to protect against both types of migraine (*Nature Genetics*, doi.org/k2zx).

The findings could lead to drugs that target the causes of migraine by inhibiting the production of the proteins coded by the *SCN11A* and *KCNK5* genes, says Stefánsson. ■

Animal intelligence

Roosters may be able to recognise themselves

Jake Buehler

ROOSTERS act differently when faced with another chicken rather than just their own reflection. This may mean that the birds can recognise themselves in a mirror, a key indicator of self-awareness.

In the traditional mirror self-recognition test, developed in 1970, researchers place a mark on an animal's body in a spot that it could only see when seeing its reflection. They note if the animal inspects or touches the mark while examining its mirror image, which suggests it understands that what it sees represents its own body. Few non-human species have passed this test, but they include some great apes, dolphins, elephants and magpies.

In recent years, there have been claims that other species – such as penguins, horses, cleaner wrasse fish and manta rays – have passed the test, but not without controversy.

A Maline rooster in front of a mirror

Results from the test are often variable. Sonja Hillemacher at the University of Bonn in Germany and her colleagues wondered if this was because there is little natural reason for many animals to investigate such marks. So, they have tried

"Self-recognition may be more common in animals than we thought"

to adapt the test to the natural behaviour of roosters, which loudly alert other chickens to the presence of nearby predators, but generally stay quiet when alone.

In the lab, they tested 68 roosters one by one in an arena divided by a wire mesh. They placed a bird on one side, and either left the other side empty or put another rooster in it. Then they added a mirror to the divider for some tests. To mimic a threat, they projected the silhouette of a hawk on the ceiling above the arena.

When a rooster was paired

with another rooster, it raised the alarm more often than when it was alone in the arena, regardless of whether it could see its own reflection. Having another rooster present but blocked from view behind a mirror led to similarly few alarms, suggesting roosters distinguish between reflection and reality through vision, not via smell or sound (*PLoS One*, doi.org/k2zm).

Since the birds acted similarly when alone and with a reflection, they may realise their reflection is of themselves, say the researchers. This means self-recognition may be more common in animals than we thought, says Hillemacher.

"This is exciting, as it moves away from the rigid dogma that the mark test is the only valid test for self-recognition," says Nathan Emery at Queen Mary University of London.

Emery thinks the traditional mark test isn't appropriate for testing self-recognition in non-apes, because most don't have hands available for easily investigating their own bodies. Notably, when Hillemacher and her colleagues put the roosters through the mark test, the birds failed.

"Ultimately, the animals are doing what they always do. We have to be the clever ones to find the right paradigms to reveal the skills they already possess," says Emery.

Hillemacher says it is premature to say chickens definitely recognise themselves in their reflections. The strange behaviour of a reflection – mimicking your movement, for instance – may be unsettling enough to perturb the natural alarm response, he says. ■



SONJA HILLEMACHER

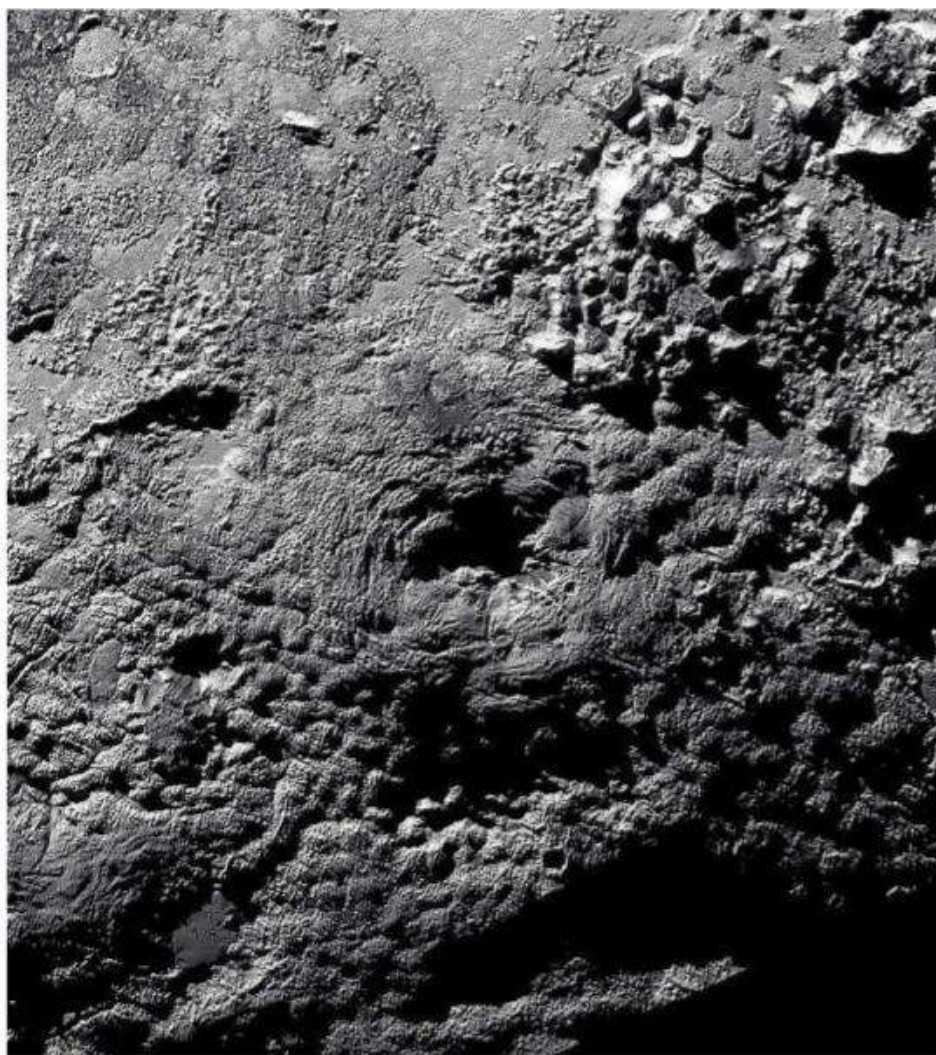
Technology

Smart glasses that help you find things

GLASSES that emit a sound when an object comes into their field of view could help people who are blind to locate certain items.

Howe Zhu at the University of Technology Sydney in Australia and his colleagues took a pair of augmented-reality glasses with front-facing cameras and built-in speakers, then paired them with a smartphone app that used deep learning to process imagery captured by the glasses to identify four objects: a bowl, cup, book and bottle. The team programmed a set sound to play when each object came into the glasses' field of view. For example, with a book, the wearer heard a page turning.

The glasses enabled people who were blind or had low vision to pick up a chosen object 81 per cent of the time (*PLoS One*, doi.org/gsx564). **Chen Ly**



NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE

Physiology

Cells may get a boost by eating viruses

OUR cells seem to get a health benefit when they engulf bacteria-killing viruses. Cells trap these viruses, known as phages, as they internalise liquid from their surroundings, but we don't know how this affects cells.

To learn more, Jeremy Barr at Monash University in Australia and his colleagues have exposed human and other mammalian cells to phages in the lab. Staining the phage's DNA let the team see when the cells had engulfed the virus.

The team found that engulfing the phages didn't trigger any inflammation in the cells, and that a signalling pathway was activated that boosts cell growth, survival and proliferation (*PLoS Biology*, doi.org/k22q). This reinforces confidence that therapies using phages to kill bacteria in the body are safe. **Kamal Nahas**

Space

Ice-spewing supervolcano may have been found on Pluto

A SUPERVOLCANO on Pluto as large as the one in Yellowstone National Park, Wyoming, may have erupted and spewed ice over the dwarf planet's surface just a few million years ago, according to an analysis of a crater found by NASA's New Horizons spacecraft.

Ice volcanoes on Pluto were first identified in images taken by New Horizons in 2015. Scientists think these volcanoes eject lumps of frozen water, instead of lava. Such icy chunks were seen on Pluto's surface during the mission.

Dale Cruikshank at NASA Ames Research Center in California and his colleagues think Pluto's Kiladze crater might be a dead or dormant supervolcano comparable to the

Yellowstone caldera, the second-largest volcano on Earth.

The first clue that Kiladze crater is volcanic is that a large portion of its rim, which is about 44 kilometres across, appears to have been shaped by a series of collapses, says Cruikshank. He and his team calculate that a volcano at Kiladze would have expelled at least 912 cubic kilometres of material (arXiv, doi.org/k22p).

The researchers also found that the area around the crater contained a lot of ammonia-rich water ice, which is thought to be found under Pluto's surface. The dwarf planet's atmosphere blankets everything on its surface in a thick layer of frozen methane, so if a probe detected water ice, it must have been put there within the past few million years to not be covered up by methane, says Cruikshank.

It is also possible the crater was formed by a big asteroid hit, or that such a collision triggered a volcanic eruption, says David Rothery at the Open University, UK. **Alex Wilkins**

Really brief



FEVZIE/SHUTTERSTOCK

Wasted food is warming the planet

FOOD rotting in landfills is a large and growing source of planet-warming methane emissions, says the US Environmental Protection Agency. In 2020 alone, US food waste released methane with a global warming effect over the next 100 years equivalent to the amount produced by 12 million fossil fuel cars in a year.

Lost flower makes a stunning return

THE mini galaxy (*Moraea minima*), a small plant with pale yellow iris-like flowers, is unique to a tiny area of South Africa. It hadn't been seen since 1981 and was thought extinct, but it has now been found blooming in the middle of a gravel road.

Super material for speedy chips

A "SUPERATOMIC" material, in which atoms form clusters that act like the original atoms in some ways, is the fastest semiconductor ever seen. Computer chips made from the material, which contains rhenium, selenium and chlorine atoms, could be thousands of times faster than ones used today (*Science*, doi.org/gszdq7).

New Scientist Discovery Tours

In the wake of Alfred Wallace cruise: Indonesia

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Explore the Spice Islands and Raja Ampat Islands as Wallace did, marvelling at their biodiversity and stunning beauty. You will cruise aboard a 22-berth luxury crewed schooner and visit several sites that were important to Wallace's discoveries. Seeing diverse species on land, in the air and at sea including several species of birds of paradise, golden birdwing butterflies and a wealth of sea creatures. Plus you will experience local culture, primary rainforests, geology, conservation projects and relaxation of the highest order.

Accompanying the cruise are three experts, George Beccaloni, an entomologist, evolutionary biologist and Wallace expert, Nita Cesar and Kees Groeneboer, cruise directors, who between them cover marine biology, ornithology, marine conservation charities, linguistics and Indonesian history. All three experts will join the daytime activities, sharing their considerable insight into the region's history, the wildlife you will find and Wallace's adventures.

Highlights

- 12 days aboard the beautiful sailing boat Ombak Putih.
- A unique programme of island exploration and evening talks.

- Explore primary rainforests, marine ecosystems and their flora and fauna, including several species of birds of paradise and Wallace's golden birdwing butterfly.
- In-depth insight into the life and work of Alfred Russel Wallace plus the natural treasures of Indonesia.
- Many opportunities to enjoy the water by kayak, paddleboard and snorkelling.

Highlights

You will travel aboard a traditional Indonesian Pinisi made from ironwood that is small enough to explore the places that large cruise ships can't and will mostly use its traditional sails to traverse the region, leading to an more elegant journey with lower impact on the region's ecology. The boat houses 22 guests in 11 spacious twin-shares with twin bunks or double beds. All cabins offer creature comforts and necessary amenities including a private bathroom. The main deck, features a saloon bar and air-conditioned dining area plus a rooftop lounge. The boat carries kayaks, two tender boats, stand-up paddleboards and snorkelling equipment, all of which will come in very useful for exploring the stunning coves and bays along the way.



*Only one berth remaining (female share)



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The columnist

Clare Wilson
examines the case
for air purifiers **p22**

Aperture

Images capture the
drama and danger
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A reader asks if
microgreens are
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Culture

What we collectively
lose when a language
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Culture columnist

Simon Ings on
a powerful film
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Comment

Martian gamble

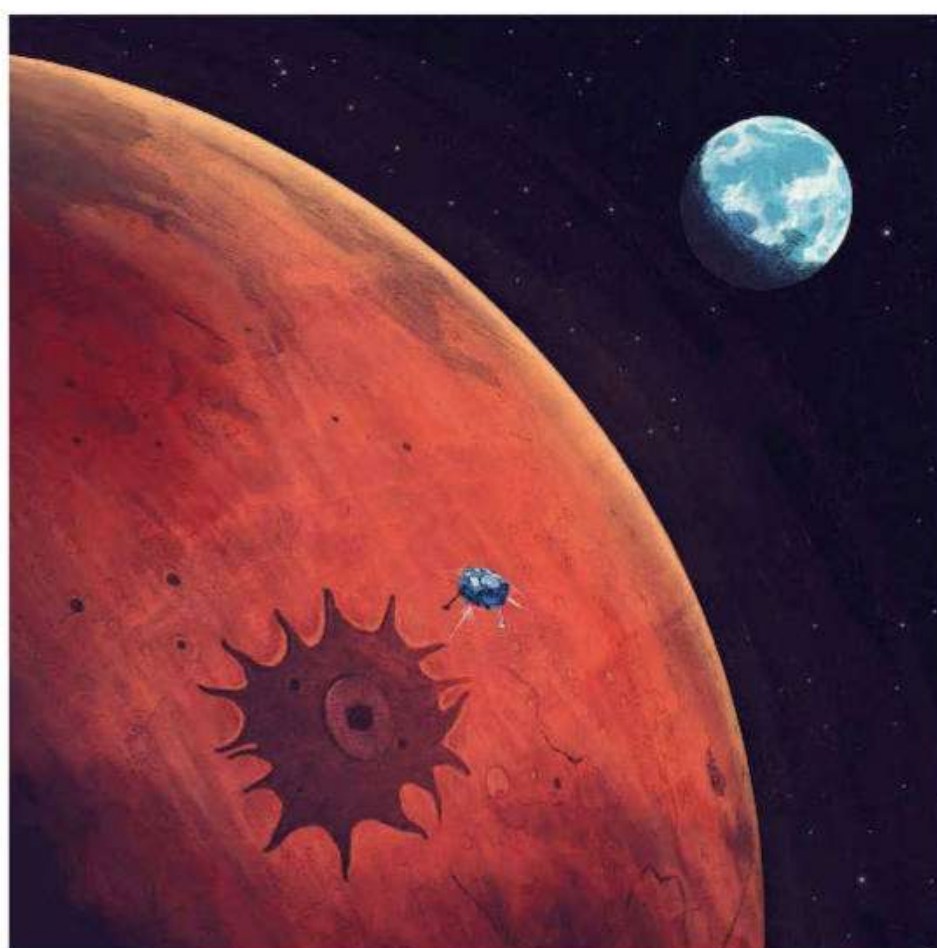
NASA's Mars Sample Return mission aims to find life, but a rethink is needed to ensure Earth's biosecurity, says **Paul Marks**

IN THE past few months, the wheels started to fall off NASA's Mars Sample Return (MSR) mission. The project aims to bring 500 grams of Martian rock and soil to Earth in 2033 to look for signs of existing or extinct life forms, but a litany of budget overruns and technology blunders have put its viability in doubt.

Not that MSR needs such problems to arouse controversy, as it is a troublesome concept all round. The reason why? There is a non-zero risk that it could deliver to Earth extraterrestrial organisms that microbiologists simply don't understand or know how to combat, nor even contain. And, if they are pathogenic, there is a risk that spilling them in a break-up of a re-entry vehicle, or a leak from a lab, could lead to ecosystem collapse or a contagion – not ideal after covid-19, which cost the US alone \$14 trillion.

So, to comply with the UN's Outer Space Treaty, which outlaws "back contamination" of Earth by returning spacecraft, NASA has been engineering this complex \$5.3 billion mission to avert such a "low-probability, yet high-consequence" outcome. In July, however, its ballooning costs provoked the US Senate to threaten cancellation. Its projected spend has now doubled: in September, a NASA report criticised the mission's "unrealistic budget and schedule expectations", estimating the true cost as nearer \$11 billion.

It got worse: among the report's



SIMONE ROTELLA

findings, it identified serious risks with a crucial back-contamination prevention technology. Once a lander retrieves sample tubes cached by the Perseverance rover, it will place them in a sealed container which a rocket will launch into Mars orbit. But the container's exterior, tainted with Martian dust, must be sterilised once captured by the mission's Earth Return Orbiter. However, the report found that a thermal sterilisation system had been swapped, with no "compelling explanation", for an ultraviolet-based system whose ability to kill microorganisms was unproven

and so not qualified for use on the mission. The report ordered government agency and independent tests on that critical UV system's efficacy.

Elsewhere, the US Fish and Wildlife Service (USFWS) has, since June, been studying a complaint from the International Committee Against Mars Sample Return (ICAMSR) about the risk to Earth's ecosystems if an invasive alien pathogen escapes from an MSR spacecraft or lab. At the time of going to press, the USFWS says it is still reviewing ICAMSR's complaint "for appropriate action". The complaint cites a report published

in the journal *BioScience* that noted that the Committee on Space Research (COSPAR), which helped NASA draw up the mission's anti-contamination protocols, hasn't consulted invasive species biologists.

COSPAR was also reproached in a blistering critique of the mission's risks published in October by the Bulletin of the Atomic Scientists – best known for the Doomsday Clock. MSR planners should consider findings on survivability under Mars-like conditions, the article says, as well as the adaptability of microbes to mutate and survive other extreme conditions – factors, it says, that are ignored in out-of-date, COSPAR-inspired procedures.

NASA is now being urged to press ahead with a cheaper MSR mission to obtain Mars samples before China does. But a bruised geopolitical ego cannot be allowed to risk Earth's biosecurity.

What is clearly needed to safely check for the presence of life on Mars, says ICAMSR, is to cancel the mission and send rovers with far more advanced life-detecting instruments to the Red Planet instead. They are right. Earth has one biosphere – and to risk it all just to assuage the curiosity of a handful of space scientists is a risk too far. ■



Paul Marks is a technology, aviation and space-flight journalist based in London

Health Check

Filtering it out We finally have evidence that air-cleaning machines reduce covid-19 sick days in schools, but it has taken too long to carry out randomised trials, says **Clare Wilson**



Clare Wilson is a reporter at *New Scientist*. She writes *New Scientist's* weekly email newsletter Health Check, about the latest health, diet and fitness news

Clare's week

What I'm reading

I have found a new favourite writer after being unable to put down Gabrielle Zevin's Tomorrow, and Tomorrow, and Tomorrow.

What I'm watching

A Haunting in Venice was terrific, even though I had to watch from between my fingers at times, it was so frightening.

What I'm working on

A story that overturns what everyone thinks we know about sleep.

TEMPERATURES have recently taken a dip in London, where I live, and, at home, I have been digging out my jumpers. At work, the winter feel is reinforced by a surge of interest in covid-19, with rising reported UK cases leading to familiar concerns over pressures on hospitals.

Because there is now much more population immunity to covid-19, it seems unlikely we would go back to restrictions on public mixing and so on. But in hospitals, where people are more vulnerable, there are questions over whether they should be reintroducing measures like staff wearing masks and having stricter isolation policies.

Even if you are tired of thinking about covid-19, the answers to these questions have broader relevance, because the same measures may well also work against other respiratory pathogens, including one that could cause a future pandemic.

Last month, figures showed that during England's second wave of covid-19, which peaked in January 2021, up to 1 in 50 people in hospitals caught the illness while they were there. This has led to renewed calls from campaigners for stricter measures to stop the spread of airborne viruses by improving air quality.

One hot topic is the use of air-cleaning machines called HEPA filters, which suck in air and absorb tiny particles such as viruses. Some argue that these machines should be put into all hospitals, schools and other public buildings. It might seem like common sense, but we shouldn't assume they would reduce the spread of covid-19. The machines – each about the size of a tall kitchen waste bin – certainly take viruses and bacteria out of any air that passes through them, but they

cannot instantly suck all the pathogens from a room. Whether they have a meaningful effect on cutting infections depends on factors such as the room size and the rate at which people are breathing out microbes.

The only way to know for sure is to do randomised trials where some buildings have the air cleaners and some don't. Two such trials have been carried out that I know of, both in the UK: one was in Addenbrooke's Hospital in Cambridge and one in 30 primary schools in the Bradford area. Their results have been eagerly awaited. Now, we

“If the machines can suck coronaviruses out of the air, they can probably do the same for other viruses, such as flu”

have had a sneak preview of the results from the schools. One of the researchers involved revealed at a recent conference that children's covid-19-related absences were 20 per cent lower in the schools with air cleaners.

It would be nice if it were higher, but I suspect this figure will be welcomed by those who have long campaigned for wider use of the machines. Certainly, any fall in the number of days that children miss school is welcome. We have to keep in mind, though, that this isn't a 20 per cent fall in their total number of sick days, only the days off caused by covid-19.

On the other hand, if the machines can suck coronaviruses out of the air, they can probably do the same for other viruses, including flu and those that cause coughs and colds, says Mark Mon-Williams at the University of Leeds, UK, one of the researchers.

Ultimately, we will have to wait until the results are published in full to properly evaluate them. And schools will still need to weigh up whether these machines are worth the cost – of several hundred pounds a unit, with two or three needed per classroom – and the fact they are somewhat noisy and can emit a cold draught.

It seems bizarre to me that, even now, three years after these machines started being installed in some hospitals in response to covid-19, we are still waiting to learn how well they work in the form of a published paper. It was a hallmark of the pandemic, though, that while there were plenty of trials of the new medicines and vaccines being developed against the coronavirus, the same scientific approach was rarely taken for physical interventions.

One of the most controversial questions of the pandemic has been over the usefulness of face masks. Wearing a face covering is backed by several major bodies. However, most of the studies cited in support of doing so are “observational”. In other words, they just observed correlations between people's mask wearing and their infection rates.

Observational studies can be biased by the fact that those who diligently wear masks tend to be health conscious in other ways too, like regularly washing their hands. When respected medical body the Cochrane Collaboration only looked at randomised trials of interventions to promote mask wearing, it found the evidence was inconclusive.

One of the common refrains during the first months of the pandemic was that policy-makers should “follow the science”. But they cannot do that unless researchers have made sure that the science has been done. ■

Up next week:
Chanda Prescod-Weinstein

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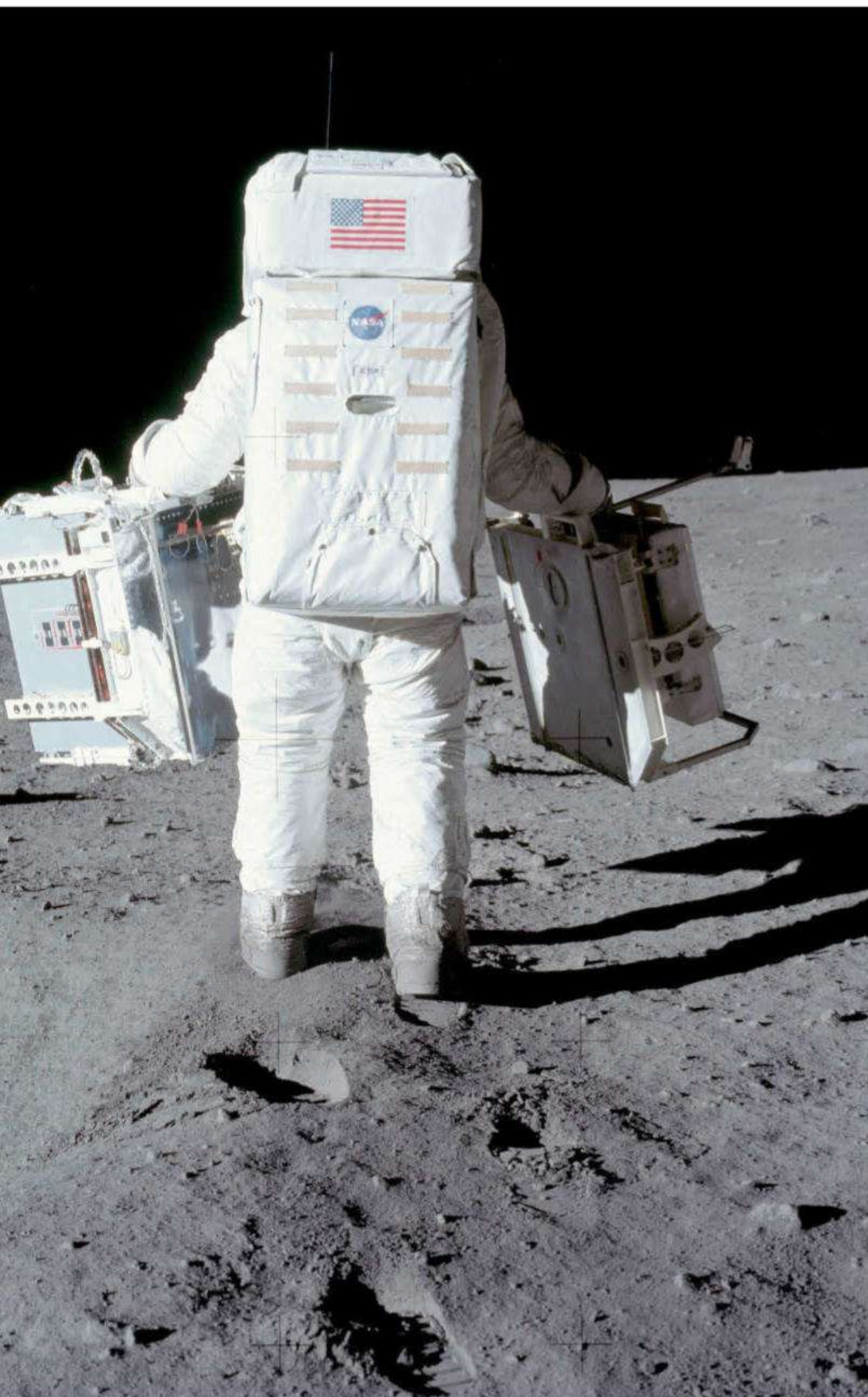
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NASA (ALL)



Boldly going



Century

SPACE, the final frontier, the stuff of dreams. Yet, in reality, a place that is fraught with danger and sometimes tragedy. This time, its dramatic tale is told by British astronaut Tim Peake in his book *Space: The human story*, from which these images are taken.

It is about the rollercoaster experience and the “absurd normality of what we try and make out our job to be – it’s ordinary people doing extraordinary jobs”, says Peake, currently an ambassador for the European Space Agency.

The main image features arguably the biggest feat so far: the first moon landing on 20 July 1969. This isn’t the iconic shot of Neil Armstrong’s first steps, but a more candid picture (taken by Armstrong) of Buzz Aldrin walking across the lunar surface.

Four days earlier, the Apollo 11 mission set off for the moon, as a striking image of its launch shows. To its left, Ed White can be seen spacewalking during the Gemini 4 mission in June 1965, which saw him suspended roughly 150 kilometres above Earth.

White and astronauts Gus Grissom and Roger Chaffee were set to crew the Apollo 1 mission (a predecessor of Apollo 11 that was meant to launch into orbit around Earth in February 1967). The image at top left shows them during capsule training. Tragically, all three died on 27 January 1967, after a fire broke out during a test.

Thinking of the future, Peake says: “We’re looking at establishing a lunar station and stepping stones to Mars. As the ISS [International Space Station] comes to its retirement, it felt like the right time to bring the whole story up to date.” ■

Gege Li

Editor's pick

Is a diet of microgreens really worth the effort?

14 October, p 36

From Roy Gray,
Macclesfield, Cheshire, UK

Microgreens may have a high density of nutrients and vitamins, but does the body absorb them all? Maybe the extras end up in the waste stream. It would be good to know how their absorption compares with that of "normal" diced raw carrots, for instance.

Rearing carnivores for meat is senseless

21 October, p 20

From John Kitchen, Kettering,
Northamptonshire, UK

On the subject of sea-farmed salmon, why do we farm carnivorous fish when, to produce 1 kilogram of them, we require a much greater weight of wild-caught fish? There is really no excuse, either environmental or economic, for doing so.

On the rise of the new forms of AI

7 October, p 20

From Nick Hunn, London, UK
Further to Alex Wilkins's piece on how large language models (LLMs) are similar to codec compression algorithms like MP3: despite the knowledge that MP3 lowered audio quality, users flocked to it, resulting in the music streaming industry of today. Convenience trumped quality. It seems the same thing will happen with LLMs.

Science isn't just for the gifted few

Letters, 14 October

From Anthony Forbes,
Durban, South Africa

The comment from a local politician that most politicians are "people persons" and aren't versed in science is both condemnatory and horrifying. Science isn't some

mystic process restricted to a gifted few. It ultimately comes down to rational, logical thought where decisions are based on real information, not gut feelings. If it is really the case that many politicians out there aren't aware of this, it is no wonder we are in our present dystopian state.

Dancing fruit and nuts have a long history

7 October, p 17

From Dave Appleby,
Eastbourne, East Sussex, UK
Your article reports research about nuts and raisins "dancing" in carbonated liquids. I taught school students to observe this phenomenon in the 1980s – I believe I found the experiment in the publications of the Nuffield Science Project.

Your account of what happens doesn't mention the fact that when the raisins reach the liquid's surface and the bubbles on top of them pop, the raisins often turn over, shedding bubbles that had been clinging to their underneath, before they sink.

There is only one substance that falls up

7 October, p 16

From Joseph Majewski,
Rindge, New Hampshire, US
The article "Antimatter definitely doesn't fall up, physicists confirm" brings to mind the element upsidaesium from the Rocky and Bullwinkle cartoons.

From John Henderson,
St Marys, Ontario, Canada
The only substance that falls up is upsidaesium, a metal found only in the floating Mount Flatten. The ill-intentioned Mr Big assigned his top agents to steal Mount Flatten.

Happily, Rocky and Bullwinkle were able to protect the world's upsidaesium supply.

I agree, non-native plants can be a boon

30 September, p 44

From Stephen Head,
Cholsey, Oxfordshire, UK
James Wong casts his habitual common sense on the issue of native and non-native garden plants. Yes, "alien" plants can be a disaster in unique ecosystems like the South African fynbos, but the UK's sparse flora has only 1625 native species compared with 1798 aliens established as unthreatening wildflowers.

Many of these are actually northern European species that would be natives if the English Channel hadn't halted their migration.

While many butterflies rely on native plants as caterpillars, pollinating insects love most horticultural plants that bloom prolifically and for long periods. Our native flora will be disrupted by now-inevitable climate change, and our long-term conservation strategy must embrace new, better-adapted species and communities.

Why the Wood Age won't quite cut it

30 September, p 14

From Mark Kaminsky,
Sunnyvale, California, US
The story "Earliest evidence of wood buildings" ends by saying "we might need to rethink our labelling of the Stone Age", that it was maybe "more of a wood age".

My understanding is that the various ages (Stone, Bronze and Iron) were named for the most common material used for knives. It is unlikely that those who

had the stone tools necessary for woodworking would have been using wooden knives, so I don't think we will soon be referring to this period as the Wood Age, even if people of the time built extensively with wood.

Let's keep an open mind on alien communication

30 September, p 29

From Ben Haller,
Ithaca, New York, US

I was a bit shocked to read Raymond Hickey's dismissal of the circle-writing by aliens that visit Earth in the movie *Arrival*. He says no animal "would use such a short-supply resource as their ink for primary communication". Why assume that it was even their own ink? Or maybe their own ink isn't, for them, a "short-supply resource" – like how urine, used for communication by many animals, isn't a scarce resource?

If we are to think usefully about talking to aliens, open-mindedness and imagination are essential.

What to call the opening age of the Anthropocene

Letters, 30 September

From Bryn Glover, Kirkby
Malzeard, North Yorkshire, UK
As discussions about a possible Anthropocene Epoch continue, it occurs to me that these seem to ignore the fact that we may need to name a new geological "age" too. The Holocene has three: Greenlandian, Northgrippian and Meghalayan.

One proposal is that the Anthropocene began in around 1750, which is the usually accepted date for the start of the industrial revolution, and marks a rapid rise in the production of goods primarily for profit rather than for necessity.

It has been proposed that, on this basis, the first age of the Anthropocene Epoch should be known as the Capitalinian. ■



Want to get in touch?

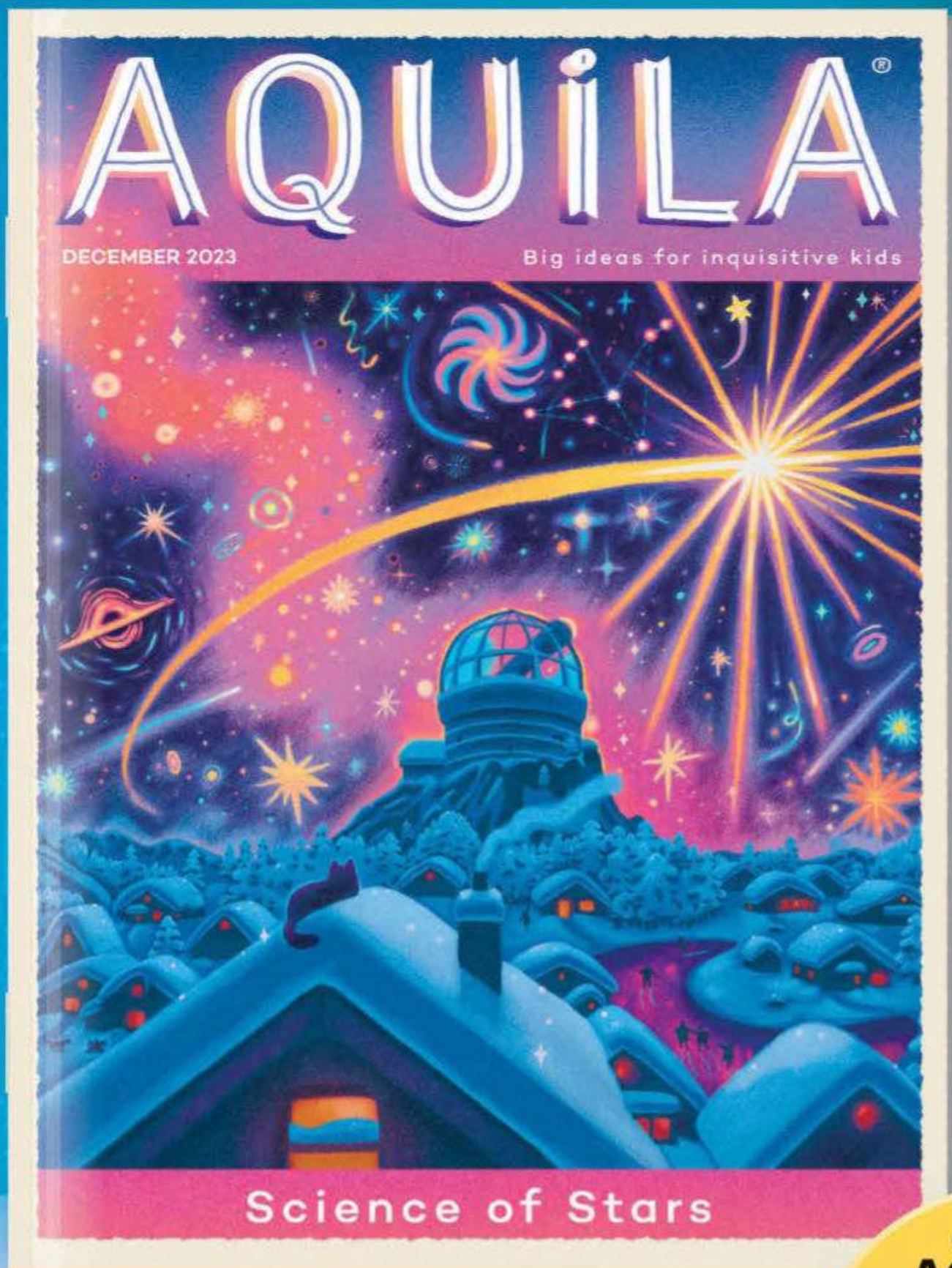
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A new road ahead

Wildlife crossings providing safe passage around roads will need global buy-in, says a rare book combining truth and hope. **Vijaysree Venkatraman** explores



Book
Crossings
Ben Goldfarb
W. W. Norton

ANYONE who has ever crossed a busy road in a metropolis without well-regulated traffic – say, Mumbai, India – will understand the plight of a deer trying to cross a rural highway in the US. Evolution hasn't prepared deer for encounters with cars or trucks.

In the US alone, over a million crashes between vehicles and large mammals occur each year, with wildlife often ending up as roadkill. Roads and fast-moving vehicles give humans mobility. But for thousands of other species, from butterflies to elephants, the same pathways act as barriers to movement, cutting off some animals from their seasonal migration routes.

Crossings: How road ecology is shaping the future of our planet is the work of environmental journalist Ben Goldfarb. He takes us on an eye-opening road trip that spans continents to show how paved roads, seen as markers of civilisation, disrupt the natural world. Mostly, he travels with researchers in road ecology, an emerging field that studies how traffic changes life for plants and animals nearby.

If roads are a disease, then wildlife crossings – a network of tunnels, overpasses and bridge-like structures that allow animals safe passage – could be the treatment, says Goldfarb. For instance, underpasses helped cut down elk fatalities on the expanded Trans-Canada Highway

A bull elk chances it on a road in Jasper National Park, Alberta, Canada



FRANS LEMMENS/ALAMY

in Banff National Park, while overpasses were found to protect grizzly bears.

The practice of road ecology, the author emphasises, is a moral mandate. Whether saving species from extinction or rescuing more common ones, animal lovers have their work cut out for them. Even roadkill, Goldfarb suggests, can be managed better to serve ecology.

The carcasses of deer, the most common roadkill, are food for scavenging birds, coyotes and even humans. But, says Goldfarb, consider the plight of the golden

eagle of the western US, which, when “weighed down by a bellyful of venison takes about as long as a 747 to achieve liftoff” and risks becoming roadkill itself. A service that drags deer carrion some distance from the road will help the eagles eat in peace.

Even the bustle of traffic can harm wildlife that relies on its keen hearing for survival. In a landmark study, researchers recorded the sound of light traffic within Glacier National Park, Montana. They then played the audio at a well-known pit stop for migrating birds in Idaho and found the noise kept some bird species away from the stretch. Songbirds that did venture into the “phantom road” had to expend so much more energy watching for predating hawks that they were too drained to forage. Consequently, they starved.

Goldfarb says that road ecology shows that “roads warp earth in every way and at every scale”. Yet the problem is only expected to get worse, as new highways are built and a projected 2 billion

A grassy overpass spares mammals the dangers of a Netherlands motorway

motorised vehicles, including self-driving cars, will hit the roads by 2030 – twice as many as in 2010.

What is to be done? In the US, there are initiatives to dismantle abandoned forest roads and to protect the migratory routes of animals. In other parts of the world, like biodiverse Brazil, new motorways come equipped with wildlife crossings and the law requires highway operators to gather roadkill data and take injured animals to clinics.

With technology and thoughtfulness, it may be possible to mitigate the worst effects. Goldfarb describes heartwarming small initiatives, such as one in Australia where people care for wallabies and other

“With technology and thoughtfulness, it may be possible to mitigate the worst effects of roads”

animals whose mothers have become roadkill, or one in Alaska, where moose roadkill is being delivered to hungry families.

Such efforts won't be enough, however. “Individual drivers can't make roads lie lighter on earth, any more than people swapping out light bulbs to solve climate change,” writes Goldfarb, making it clear it will have to be a colossal, planet-wide effort.

This is a rare, beautifully written book, which tells us hard truths about roads, cars and life on Earth, but still manages to make us feel positive about the road ahead. ■

Vijaysree Venkatraman is a science journalist based in Boston



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Tim Boddy
Picture editor
London, UK

Music, drag, colour, garish looks, enchanting queer people – just my regular Saturday night. But this was London's Royal Botanic Gardens, Kew, during its delightful **Queer Nature: After hours** event, a party for the **Queer Nature** celebration of diversity in plants and fungi.

Among the art and the performances, I loved drag king Beau Jangles singing 40s-inspired songs, DJ Auntie Maureen (pictured), and Jeffrey Gibson's "House of Spirits", a radiant,



large-scale artwork, suspended in Kew's Temperate House.

But my highlight was strolling around taking in facts on bisexual flowers and asexual trees, while enjoying the fun, inclusive vibe. Humans can learn a lot from nature's diversity.

Earlier in the day, I saw **RE/SISTERS** at London's Barbican, an exhibition exploring the relationship between gender and ecology. It included some of my favourite photographers, such as Fay Godwin, Sim Chi Yin and Poulomi Basu. More sobering than Kew's offering, but equally vital.

Our language, our lives

Invaluable insights into the human mind may disappear with the extinction of thousands of languages, finds **Colin Barras**



Book

A Myriad of Tongues

Caleb Everett

Harvard University Press

THE 7400 or so languages in use today speak to the fact that our species is primed to communicate. But while it is tempting to view language as merely a consequence of our extraordinary cognitive powers, Caleb Everett thinks there may be more going on.

In *A Myriad of Tongues: How languages reveal differences in how we think*, he argues that language itself may shape our understanding of the world and our experience of time and space. To put it another way, the language we speak may influence the way we think.

Such a provocative idea might have been controversial a few decades ago, says Everett, because linguists restricted themselves to analysing languages of industrialised, higher-income countries. These are relatively similar, so they encourage speakers to think along broadly similar lines, he says. But we now know they fall short of representing the variety of languages spoken today – and the

more we learn about understudied tongues, the more evidence we find for the complicated interplay between language and thinking.

Take Berinmo, a language of Papua New Guinea. Unlike English speakers, explains Everett, Berinmo speakers struggle to remember whether an object they were shown earlier was blue or green – perhaps because that language doesn't distinguish between these colours. But it does make a formal distinction between yellowish-greens and other greens, and Berinmo speakers typically find it easy to remember which of these colours an object they saw earlier was painted, while English speakers struggle to do this.

Language also influences how we think about objects, writes Everett. Yucatec Maya, spoken in Mexico, Guatemala and northern Belize, encourages its speakers to classify objects according to their material properties rather than their function. Where an English speaker might group a plastic comb and a wooden comb together and exclude a wooden stick, a Yucatec Maya speaker would usually group

Understudied languages spoken by Indigenous communities are in danger of disappearing

the wooden objects together. To do so, they would often carefully evaluate objects, checking weight, malleability, taste and smell. English-speaking people in the US get the information they need by sight alone, Everett explains.

As a professor of anthropology and psychology at the University of Miami in Florida, Everett is a confident guide to this new perspective, and with good reason: he grew up with the field from childhood. His father, Daniel Everett, is a linguist famous for his research into the culture and language of the Pirahã people of the Amazon basin.

This language (also called Pirahã) has many striking features influencing the way its speakers view the world. Its lack of number words, for instance, makes it impossible to measure time in quantifiable units. The young Caleb accompanied his father on research trips. As he recounts: "I have spent more evenings and afternoons than I could count swimming *Piibooxio xigahapaati* [upriver] in the cool waters of the Maici". It is easy to imagine this kindling his fascination with language and cognition.

His book, then, celebrates two main subjects: understudied languages, with the fascinating insights they offer, and the careful work of linguists, anthropologists, cognitive scientists and others to explore the way language influences our thinking.

As Everett stresses, this work is vital as we live through a language extinction event predicted to see the loss of about 30 per cent of today's tongues by 2100. His book makes it clear this is more than just a tragedy for local communities. Given the insights that languages offer into the human mind, their disappearance is a loss for us all. ■

Colin Barras is a science writer based in Ann Arbor, Michigan



The film column

Remember this A poignant and powerful meditation on memory tells the story of Chilean writer and journalist Augusto Góngora, whose collection of remembrances helped Chile regain its national identity after its dictatorship fell, says **Simon Ings**



Simon Ings is a novelist and science writer. Follow him on Instagram @simon_ings



Augusto Góngora and Paulina Urrutia in their home

account. Early on, we see Urrutia taking the couple's portrait off the bedroom wall before they sleep. If she doesn't, the sight of two strangers staring down in the night might send Góngora into a panic.

His deterioration is relentless: soon he is talking to the stranger in mirrors and glass doors. "Something very strange is happening here," he muses. Soon, he won't even recognise Urrutia.

Her plight is given its proper due. Tirelessly, she recites the facts of her lover's life to him and, for a while, this brings comfort. "They're always with me," he mutters, over and over, "and they love me, every day." But no respite lasts, and the toll on Urrutia is shocking.

What's extraordinary is that, even as the film records the disintegration of memory in an individual, it celebrates the way memories – in books, spoken to camera or transmuted into art, drama or music – work collectively to bring a nation back to life.

Because, for all the sadness here, Góngora, through his films and the written collection of remembrances *La Memoria Prohibida* (*The Forbidden Memory*) kept the memory of his country alive and preserved its identity. One line from the collection echoes throughout: "Without memory, there is no identity." Near the end of the film, Góngora weeps: "I'm not myself any more." But even as he loses his identity, Chileans are seen regaining theirs.

At a time when the idea of national identity is often little more than a political football, it is worth remembering that a people's idea of itself is a living thing, worth defending against the amnesia of tyrants. ■



Film

The Eternal Memory

Maite Alberdi

10 November UK;

Streaming in the US

Simon also recommends...

Books

Travellers to Unimaginable Lands

Dasha Kiper

Profile Books

People caring for those with Alzheimer's are invisible victims of the condition in a work that records the bravery and tragedy shaping many ordinary lives.

Flowers for Algernon

Daniel Keyes

Weidenfeld & Nicolson

Teaching students with special needs inspired this story about the remarkable flourishing and slow, sad decline of a man given drugs to make him smarter.

SOMETIMES, to really understand a process, you have to follow it, without flinching, even if it upsets you, even if it breaks your heart.

Oscar-nominated director Maite Alberdi won a Sundance Film Festival Grand Jury prize this year for *The Eternal Memory*, a documentary partly made from original footage, home movies, newsreels and videotapes smuggled out of Chile during the darkest years of General Augusto Pinochet's 17-year dictatorship.

Its subject is Chilean writer and journalist Augusto Góngora, who is living (and by the last reel, very obviously dying) with Alzheimer's disease. Góngora died earlier this year aged 71. Between 1973 and 1990, as part of an attempt to document and share Chile's national turmoil and horror, he edited an opposition newspaper and made VHS recordings of life and the struggle under Pinochet.

It was dangerous work. In 1985, a fellow journalist on the project, José Manuel Parada, had his throat slit. This haunts Góngora, whose sense of self comes to depend increasingly on the presence (real

or imagined) of friends and family.

From 1990, he spent 18 years interviewing writers, film-makers, artists and musicians for TV – people he believed could help bring the newly democratised nation out of its forced (book-banned, movie-less) forgetfulness and reawaken its once vibrant culture.

Diagnosed with Alzheimer's disease in 2014, Góngora readily embraced the plan proposed by

"Urrutia's plight is given its due. She recites the facts of her lover's life to him and, for a while, this brings comfort"

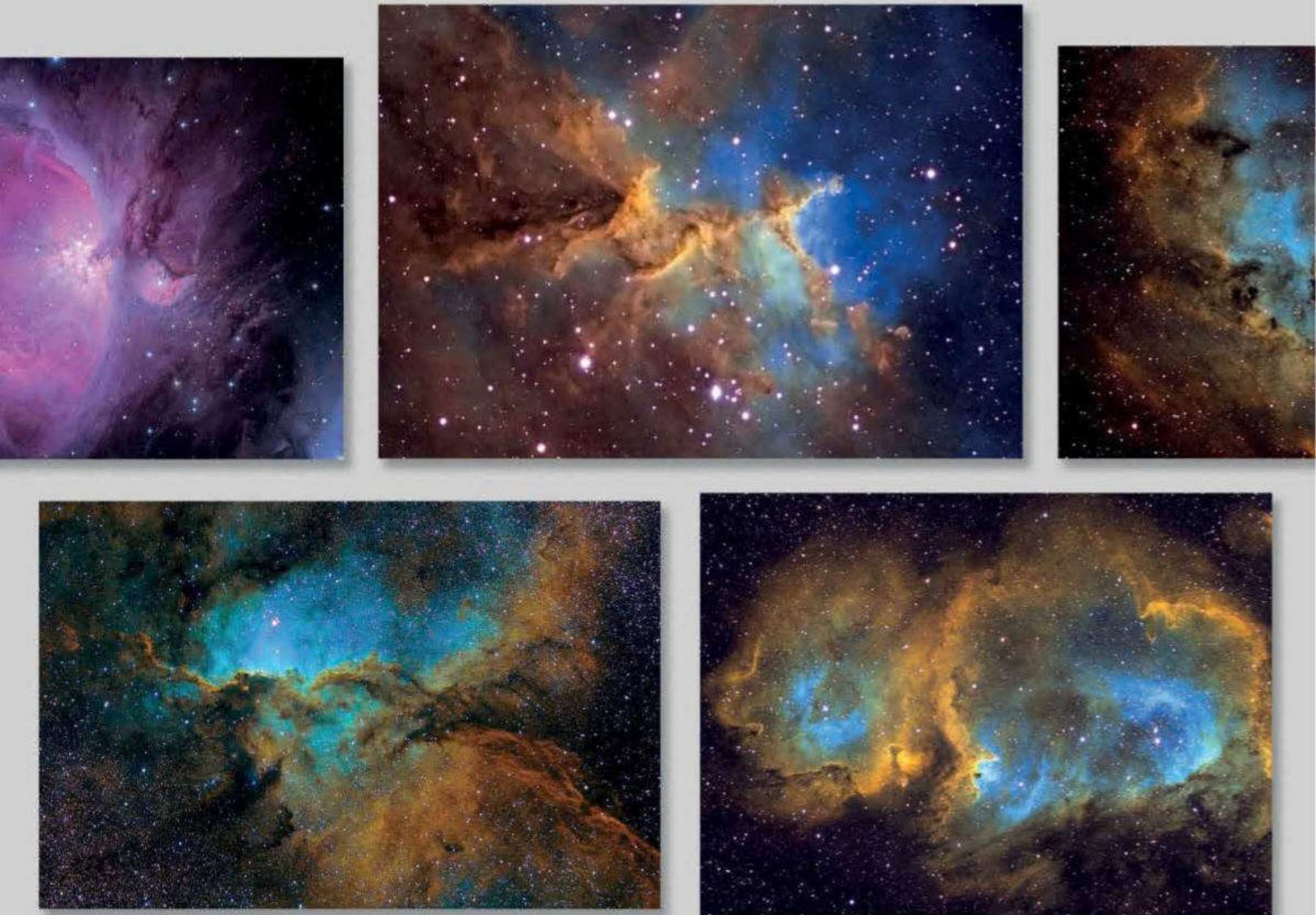
his wife, the actor and politician Paulina Urrutia, to record his physical and cognitive decline. Such a record would, at the very least, be a testament to 25 years together. Assembled, edited and capstoned with new footage, *The Eternal Memory* is that and more: it is a meditation on what we can and cannot expect from memory.

The spine of the film is an honest, frank, never voyeuristic

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Are you healthy?

It is a surprisingly difficult question to answer. But a new generation of tests, based on emerging insights into human biology, offers a way to find out, says **Helen Thomson**

I'M WELL, thank you. Or at least I think I am. I have no major illness to speak of, I am of average weight and a recent knee scan showed my joints are sufficiently well oiled. My blood pressure is spot on and I exercise fairly regularly – at least, some of the time. Then again, I have a cough I can't shake. I don't feel physically strong. And since I am turning 40, I should really get a mammogram, given my family history of breast cancer.

So, am I healthy? With my "big birthday" looming, I have increasingly found myself wondering about that – about what it is to be healthy and how we can best measure whether we are or not. I had assumed there would be some well-established way to find out. But when I began to investigate, I soon discovered that it is a surprisingly hard question to answer.

That is partly because we now know that many of the metrics we rely on, such as body mass index (BMI), are flawed. But it is also the result of fresh insights into the microbiome and the immune system, among other things. These are giving rise to a whole new raft of tests promising a better gauge of health – from those that probe your gut bacteria or your metabolites to those that provide you with an "immune grade". So, which of these new tests, if any, should I be turning to for the ultimate health check?

Your common-sense definition of what it means to be healthy probably roughly aligns with what the dictionary says – namely, that health is "the condition of the body and the degree to which it is free from illness", to borrow from the *Cambridge Dictionary*.

The World Health Organization (WHO) is a little stricter. It defines health as "a state of complete physical, mental and social well-

being and not merely the absence of disease". Although this definition was adopted by 61 countries in 1946, it has since been criticised. The requirement for "complete" well-being means most of us would qualify as unhealthy most of the time. Another obvious problem is that you can feel perfectly healthy while having a chronic illness or life-limiting condition.

Without a definition of what health is that everyone can agree on, it is no wonder that coming up with an adequate test for it is challenging. "Sometimes, the simplest of questions are the hardest to answer," says epidemiologist Margaret Harris at the WHO.

"YOUR MICROBIOME REFLECTS THE HEALTH OF MOST OF THE SYSTEMS OF THE BODY"

Ask your doctor and, assuming you don't have any major complaints, they would probably start by taking your blood pressure and checking your BMI, a measure of weight that takes your height into account. But, on closer inspection, each has its problems.

In most high-income countries, a BMI between 18.5 and 24.9 is viewed as healthy. Anyone with a BMI of 25 or over is considered overweight; beyond 30 they are classed as obese. But while it is uncontroversial that obesity is linked to conditions such as cardiovascular disease, stroke and type 2 diabetes, it is unclear where the cut-off should be for being classed as overweight.

Questions first arose in 2005, when a study

showed that people with a BMI between 25 and 30 had a lower death rate than those whose BMI was in the supposedly healthy range. Further doubts came in July from a large study of US adults showing that a BMI of between 25 and 29.9 was linked with a 5 to 7 per cent lower risk of death over the study period compared with a BMI value in the supposedly healthier category of 22.5 to 24.9.

Blood pressure, meanwhile, is limited in the sense that it can only really tell you about a handful of conditions. With that said, it is still a good starting point, says Harris. "It can tell a doctor whether you have signs of cardiac disease or are anaemic, which a lot of people are." She adds that regular, age-appropriate screening tests are also important for catching hidden conditions, such as cervical cancer.

So it isn't as though the tests we have are useless. But as we have discovered more about the immense complexity of the human body, it has become increasingly clear that they can't fully capture our deepening understanding of what it really means to be healthy.

To get to grips with that, I spoke to Tim Spector, a geneticist at King's College London who has dedicated much of his career to tracking people's microbiomes – the myriad microbes that live in and on our bodies that have a huge impact on us, from our ability to digest food to our immune health, heart health and mood. Unsurprisingly, Spector's first suggestion centres on just that. "If you want to know how healthy you are, the first thing you should do is test your microbiome," he says. "Your microbiome reflects the health of most of the systems of the body. It's a catch-all."

The problem, until recently, was that we had no strong evidence of what a healthy gut ➤



FIVE QUICK WAYS TO JUDGE YOUR HEALTH

LOOK IN THE MIRROR

Your skin is an integral barrier that protects your body from a number of insults. Some researchers now suspect that wrinkles aren't only a result of ageing, but a cause of it too. As skin degrades, it produces zombie-like cells that spew out chemicals that flow around the body doing damage. So, if your skin is less youthful than that of others your age, it might be telling you something.

GET A GRIP

Several studies have determined that grip strength is a more powerful predictor of dying from cardiovascular disease than blood pressure, and that it is associated with risk of falls, cognitive problems, insomnia, depression and mortality. Noticing a decrease in grip strength might be a red flag.

COUNT YOUR COLDS

In January, Jenna Macciochi, an immunologist at the University of Sussex, UK, told *New Scientist* that the average person should expect to have one or two mild illnesses a year. If you get sick more than this, and if your illnesses last longer than other people's, it might be a sign that you aren't as healthy as you could be.

THINK ABOUT YESTERDAY

Think about how you feel today compared with last month. "Have you gone up or down a dress size? Has your sleeping pattern become better or worse?" says Margaret Harris at the World Health Organization. Comparing your current self to your past self offers a good insight into whether you are healthy – albeit using yourself as the benchmark.

ASK YOURSELF HOW YOU FEEL

Self-rated health scores correlate with many blood markers of health. But even when you control for these, people who subjectively "feel" better tend to live longer. Even among people with terminal cancer, those who rate their health as excellent outlive those with the same diagnosis but who rate their health as poor. Research is ongoing to understand the nature of subjective health experience and what this tells us about our underlying health.

microbiome looks like. The best advice was to aim for a good diversity of gut bacteria. In October, though, having analysed more than 100,000 microbiomes, Spector and his team announced that they had identified 50 "good" and 50 "bad" types of bacteria, the balance of which appears to be a good indicator of health. "If you're looking for a holistic test of different aspects of health, then that's the one to go for," says Spector, who helped to develop Zoe, an app that

"DOES MY PARTNER'S ABILITY TO SIDESTEP A COLD SHOW THAT HE IS HEALTHIER THAN ME?"

offers these tests. When I do my own microbiome test, I get a score of 66 out of 100, which puts me in the "good" category, meaning I have a relatively healthy ratio of good to bad bacteria.

Anna Valdes at the University of Nottingham, UK, thinks it is fair to say that there is a strong association between the microbiome and a number of chronic and acute conditions. It is also true that your gut bacteria can change dramatically in response to an infection, diet or chronic illness, she says, sometimes within days, so testing it can reflect your current health status.

Even so, microbiome testing does have its limitations, not least because "a specific microbiome composition isn't good for everything for every person", says Valdes. It is generally accepted that it is beneficial to have butyrate-producing bacteria, for instance, on the basis that they are involved in brain health, glucose tolerance and wound healing – and even prevent the proliferation of some cancer cells. If you have ulcers, however, butyrate can hinder their healing.

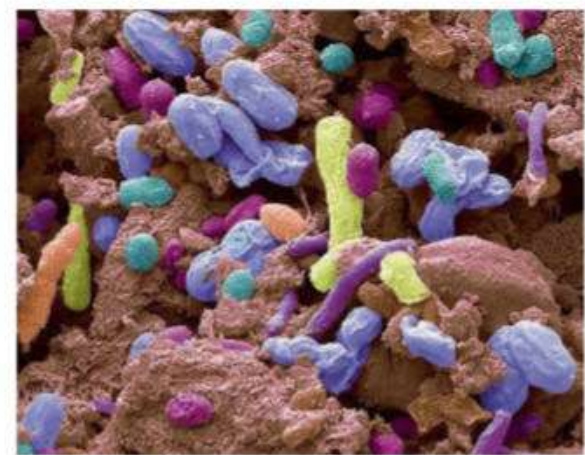
Spector's second recommendation is to test your "metabolome". This shows the breakdown products from metabolic processes, the chemical reactions in your body's cells. The reason it makes for a good measure of health is that certain combinations of metabolites can be used as a marker of your current condition and future disease risk. Several companies offer such tests, which start at around £65.

Earlier this year, a group of international researchers combined metabolite data with blood fat data from more than 118,000 participants of UK Biobank – the world's largest repository of metabolic biomarkers linked to health records – to create an atlas of associations between metabolites and more than 700 common conditions. The authors say that, although the striking similarity of some patterns of biomarkers across various diseases may pose problems for detecting specific conditions, metabolites are ideal for informing someone about their overall health.

Spector's final recommendation is a test of biological age, in which you gauge how various aspects of your body are ageing compared with your chronological age. This pleases me because, five years ago, I got my "glycan age" tested. Glycans are complex carbohydrates that attach to other molecules in the body. Just how they glom onto an antibody called immunoglobulin G changes as we get older, which means they can be used to predict how fast your body is ageing relative to your years. My glycan age was 13 years younger than my actual age, which is good news because people who have high insulin levels, high cholesterol and other markers of ill health, also have an older glycan age.

All of which sounds satisfyingly scientific. But one of the things I really want to know is why my partner never seems to get sick when I am always coming down with something. Is his ability to sidestep a cold a sign that he is generally healthier than me?

I was surprised to find that this isn't the kind of question a lot of scientists seek to address. "They are more focused on treating disease than maintaining health," says Sunil Ahuja at



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A gut microbiome test offers a snapshot of overall health



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Your immune system's resilience declines with age

the University of Texas Health Science Center at San Antonio. But he and his team have been attempting to better understand health, and what they have found suggests it partly comes down to immune resilience, or how well your immune system can deal with daily challenges.

By studying the blood cells of more than 40,000 people, Ahuja and his colleagues found that the balance between two types of immune cells called T-cells correlates with how you respond to physiological challenges, such as viruses or cancer. Those who responded best had a high level of a kind of T-cell called CD4, associated with resilience, and a low level of one called CD8, associated with inflammation, which is a vital process for eliminating pathogens but also underlies many diseases. They also looked at two sets of genes related to immune resilience and inflammation.

The researchers graded participants based on these metrics: grade 1 had the highest immune resilience, whereas grade 4 had the lowest. They found those with grade 1 were more likely to avoid symptoms from flu, more likely to resist being infected with HIV, had longer periods of time between recurrent skin cancers, were more likely to survive sepsis and covid-19, and had longer lifespans in general.

Women were more likely to have a better grade than men and, generally, everyone's immune grades tended to worsen as they aged,

or as they were exposed to infections or other illnesses. Intriguingly, however, there were some people in this cohort who maintained an excellent immune grade even into their 90s. "It might be a better reflection of health than age, when it comes to things like how you'll react to covid-19," says Ahuja. "We saw many older people who were grade 1 and immunologically healthier than a younger person who's a grade 4."

Immune score

You can discover your immune grade with a simple blood test. If your T-cell ratio comes back worse than expected, it might be time to invest in a bit more exercise. Ahuja and his team gave a small group of people a 24-week exercise regime, taking their immune grade at various points throughout the study. In work that is yet to be published, they found that everyone's immune grade improved by the end of the study. Then came the big reveal: after taking a two-week break from the regime, the whole group's immune grade went back to baseline. "Evolutionarily, we weren't designed to sit on our asses," says Ahuja.

It is a tough pill to swallow, given my fickle relationship with exercise. I am beginning to think that I don't want to take any more health tests. It is all starting to feel quite stressful, which brings us to mental health.

Harris says there are plenty of good tests online that assess your happiness, sleep, anxiety levels and such, screening you for

everything from attention deficit hyperactivity disorder to depression, addiction and eating disorders. These are a good starting point, she says. If you are worried about your mental health, a single test isn't going to cut it and you should see a doctor. But one way to take stock may be found closer to home: "Just ask the person who knows you best. We've found they are often the best person to tell you whether you seem [mentally] healthy or not," says Harris.

Perhaps searching for a single comprehensive test is where I am going wrong. In their own quest for the hallmarks of health, Carlos López-Otín at the University of Oviedo, Spain, and Guido Kroemer at the European Research Institute for Integrated Cellular Pathology in Paris came to the conclusion that such hallmarks aren't confined to a particular molecule or even a whole system, but should be conceived as a series of "dynamic features that maintain the precarious equilibrium preceding disease". In other words, health is homeostasis: the ability to rapidly correct things when they venture off-piste.

The pair's compendium of dynamic features includes things like your ability to heal after an injury, the speed at which you are able to correct your blood sugar after a dessert and the integrity of the physical barriers that help maintain your brain and body. Disruption of any of these derails our health, they say.

Their list of homeostatic processes is lengthy and impossible to test in full. But the research suggests we are on the right track with some of the aforementioned criteria – your immune resilience, for one. It also demonstrates the importance of skin health and other easy-to-test aspects of your physiology (see "Five quick ways to judge your health", left).

Clearly, there is no all-encompassing test of health. But taken together, a handful of these new measures can offer a much clearer picture of what it means to be healthy and where a given person is at that moment. As for me, I can at least approach my 40th birthday feeling that I am in pretty good shape. I don't have "complete well-being", by any means, but I am happy and – as far as some of the most advanced tests can tell – reasonably healthy. ■



Helen Thomson is head of features at New Scientist

The elusive origins of life

Seventy years ago, we were poised to understand how life on Earth began. **Michael Marshall** explains why the mystery endures, and how we're going to crack it

HOW did life on Earth begin? Until 70 years ago, generations of scientists had failed to throw much light on biology's murky beginnings. But then came three crucial findings in quick succession.

In April 1953, the race to uncover the structure of DNA reached its climax. Geneticists soon realised that its double helix form could help explain how life replicates itself – a fundamental property thought to have appeared at or around the origin of life. Just three weeks later, news broke of the astonishing Miller-Urey experiment, which showed how a simple cocktail of chemicals could spontaneously generate amino acids, vital for building the molecules of life. Finally, in September 1953, we gained our first accurate estimate for the age of Earth, giving us a clearer idea of exactly how old life might be.

At that point, we seemed poised to finally understand life's origins. Today, conclusive answers remain elusive. But the past few years have brought real signs of progress.

For instance, we have found that life's ability to replicate is not wholly reliant on DNA. We also have a far better idea of the conditions on early Earth when life first appeared – and we are beginning to conduct experiments into how it emerged that are much more sophisticated than Miller-Urey.

So, 70 years on from that incredible year of breakthroughs, how has our picture of life's origins changed? And what remains to be figured out before we can satisfactorily answer biology's ultimate question?

"I think in the 50s we knew very little about life," says Joana Xavier at Dayhoff Labs, a company that builds AI models for biochemistry, in London. While it was clear that all life is made of cells, the inner workings of those cells were almost entirely mysterious.

The molecular biology revolution changed all that, and it arguably started in 1953. On 25 April, James Watson and Francis Crick published a seminal paper describing the structure of DNA. Otherwise known as deoxyribonucleic acid, DNA had already been identified as the molecule that carries all our genes. Watson and Crick were one of several groups trying to figure out its shape. Inspired in part by X-ray crystallography images obtained by Rosalind Franklin, they worked out that DNA is a double helix: it is made up of two long chains that twist around each other.

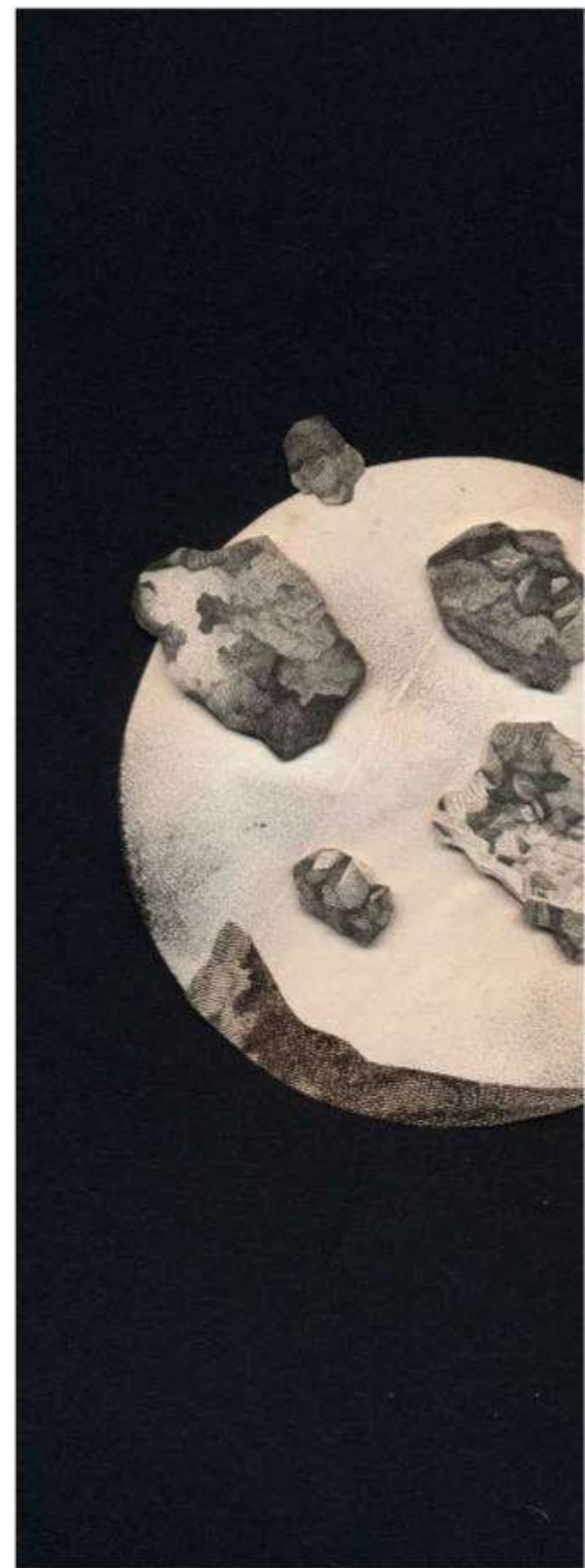
Chemical landscapes

This discovery led to an explosion of research. In short order, biochemists revealed how information is encoded in the sequence of building blocks that make up the DNA molecule, and how the sequence is used to construct the complex proteins from which organisms are made.

But what biologists of the 1950s couldn't know is just how extraordinarily intricate even the simplest of living cells are. A 2022 study reported the first full three-dimensional model of a bacterial cell. The researchers chose a parasitic species called *Mycoplasma*

genitalium, because it has relatively few genes and therefore presented less of a computational challenge. Nevertheless, just figuring out the shapes of the protein molecules took more than eight months. In other words, life is complicated – much more so than we thought 70 years ago.

This new appreciation of life's complexity has broader implications. For instance, in the years that followed the discovery of the DNA double helix, many biologists began viewing living things through a lens of reproduction and heredity. Life, in this view, is all about the genetic information that is passed on





NICOLE NATRI

from generation to generation.

In recent decades, however, it has become increasingly clear that life isn't just about the genome. For example, living cells are highly dynamic, with components constantly moving and transforming, all largely in an effort to maintain a kind of stability. So we now know that reducing life to one or two components or processes is a mistake.

This helps explain why biology has yet to settle on a clear definition of "life" that commands widespread support. This isn't for want of trying: a review published a decade ago identified 123 distinct definitions of life. And

they keep coming: one new idea to emerge is Assembly Theory, which proposes that there is a universal process through which matter can evolve complexity through time, with life defined as a point at which a certain level of complexity has been reached.

At first glance, this struggle to define life suggests we are hopelessly far from unravelling its origins. But it is possible to take another view. With our appreciation of the complexity of life comes the realisation that there are many theoretical pathways by which mixtures of chemicals could have self-assembled into the first organisms.

This means it has become clearer over the past 70 years that, somewhat surprisingly, we may not actually need to wait for an agreed definition of life in order to understand its origins. Rather than beginning with a clever but incomplete description – such as a single canonical process – and then trying to work out how to arrive at that destination from a cocktail of chemicals, some researchers are instead exploring the chemical landscape that gave rise to living organisms. The hope is that we can work out which properties of life plausibly appeared first through experiments designed to recreate the early



stages in its emergence. “It will come down to understanding the feasibility of chemistry,” says Betül Kaçar at the University of Wisconsin-Madison. But to understand that feasibility, researchers first need to establish what Earth was like when life appeared.

For most of human history, it was impossible to say much about the conditions that existed when life originated, for the simple reason that we had no hard evidence about the age of Earth or the biosphere. With the discovery of radioactivity in 1896, a path opened to finding the planet’s true age. Every radioactive element decays at a specific rate, some over the course of hundreds of millions of years. Given that some of these elements are found in rocks, the discovery offered a way to calculate their age and, by extension, that of Earth. But there is a catch: Earth is a geologically active place, so rocks are continually destroyed and created, meaning few of them are as old as the planet.

The key was to find rocks that had formed at the same time as Earth, and by the 1950s, geologists had a solution: meteorites. These chunks of rock – the same sort of material that had coalesced to form our planet – had drifted through the solar system since Earth’s birth, before crash-landing here.

At a conference in September 1953, Clair Patterson at the California Institute of Technology and his colleagues revealed that they had analysed fragments of the Canyon Diablo meteorite, which formed the famous Meteor crater in Arizona. By measuring how much of the meteorite’s uranium had decayed into lead, they determined that it – and so Earth – was 4.55 billion years old. However, the first to publish the finding was physicist Fritz Houtermans at the University of Bern, Switzerland, in December 1953. He calculated an age of 4.5 billion years after being sent information about Patterson’s research.

We finally knew that life may have existed on Earth for billions of years. But it was unclear in 1953 exactly when it had originated and what the conditions on our planet were like when it did so. This uncertainty wasn’t helped by the fact that the oldest known fossils at the time were little more than half a billion years old.

However, older fossils soon emerged. In 1957, for example, palaeontologists described a frond-like fossil, known as *Charnia*, from the UK that we now know is about 570 million years old. Since then, the age of the oldest known fossils has been pushed much further back in time: a 2019 study found strong evidence that 3.5-billion-year-old rocks in Pilbara, Australia, contain the preserved remains of single-celled microorganisms.



Clockwise from left:
Charnia fossil, early
conditions on Earth and the
Canyon Diablo meteorite

SABENA JANE BLACKBIRD/ALAMY; MARK GARLICK/SPL/ALAMY; MATTEO CHINELLATO/ALAMY

“The organism that gave rise to life on Earth existed at least 3.9 billion years ago”

Moreover, based on what we know about the evolutionary tree of life, some researchers argue that the last universal common ancestor – an organism that gave rise to everything living today – existed at least 3.9 billion years ago.

Crucially, we now have a much better idea of what our planet was like at that time. In the past 20 years, we have learned that Earth probably cooled and gained oceans that could, in principle, have supported life by

about 4.2 billion years ago. “It’s much more widely accepted in the past few years that there was water on the early earth,” says Beth A. Bell at the University of California, Los Angeles. Dry land may have arrived early too, with evidence for its presence by 3.7 billion years ago.

This means we now understand there was no shortage of environments for life to emerge, both on land and in the sea. Over the past 70 years, we have learned a great deal about how it might have done so.

The foundational experiment in creating life from scratch was conducted in late 1952, and published on 15 May 1953. A young graduate student at the University of Chicago named Stanley Miller wanted to find out if the molecules of life could have formed on the early earth. At the time, little was known of Earth’s earliest history, but Miller did his best to recreate plausible conditions.

He designed an apparatus consisting of two glass flasks, linked by tubes. One flask held water, mimicking the oceans Miller assumed

would have existed. It could be heated, as Miller also reasoned there were lots of volcanoes on the young planet. The other flask represented the early atmosphere and contained a mix of methane, ammonia and hydrogen. Miller also inserted an electrode to simulate lightning strikes.

After just a few days, the water turned first yellow and then brown. When Miller analysed the resulting mixture, he found it contained glycine. This is the simplest of the amino acids, which are the building blocks of proteins. Amino acids are essential to life as we know it, and Miller had shown that they could form spontaneously under natural conditions.

Life's foundations

Miller's supervisor, the chemist Harold Urey, selflessly told Miller to take sole credit for the work. Nevertheless, the set-up is often known as the Miller-Urey experiment. Seven decades later, "it is still the experiment that the public knows most intimately", says Xavier.

However, although amino acids are important for life, they are also found in lifeless settings – including deep space – so they don't tell us very much on their own. "Making amino acids is not making life," says Xavier. The question then becomes, which of life's fundamental processes came first?

As we have already seen, some researchers insist that genetics was one of life's foundational features. But few of them now think this means DNA was present in the first organisms. Rather, some argue that life began with RNA, a molecular cousin of DNA with a wider range of properties including, importantly, the ability to control the rates of chemical reactions crucial to life. In line with this, over the past 40 years, chemists have demonstrated that RNA can perform many of the functions of life. They have, for instance, shown it is possible to make RNA molecules that, with minimal help, can reliably copy other RNA strands they encounter.

Meanwhile, Ryo Mizuuchi at Waseda University in Tokyo, Japan, has shown that, once assembled, RNAs can behave in a way that resembles features of a living entity. Last year, he and his colleagues showed that a single RNA strand could evolve into five "lineages" with distinct genetic properties – perhaps a precursor to distinct genes in a full genome.

But even Mizuuchi suspects it might be too simplistic to focus exclusively on RNA. Other biomolecules are likely to have been just as important, he says. For instance, other researchers consider metabolism,

the reactions that underpin life's ability to nourish and sustain itself. These processes are fiendishly complex, and in modern organisms they are controlled by battalions of enzymes – a special kind of protein. However, since 2014, a string of experiments has revealed that many of the reactions can take place spontaneously in water, with no need for enzymes. A few simple metals – such as iron, nickel and cobalt, which are common in nature – are enough to make the reactions happen.

Xavier and her colleagues are searching for a more general version of these chemical networks. She argues the key to life is "autocatalysis" – the ability of a set of molecules to react together in order to replicate themselves.

In 2022, Xavier and her colleague Stuart Kauffman at the Institute for Systems Biology in Seattle mapped the networks of chemical reactions that take place in single-celled microbes. They looked at 6683 different networks: every single one contained a set of molecules and reactions that could perform autocatalysis. The implication is that this ability is pretty common.

However, there is a twist. Xavier argues that the autocatalytic networks in living organisms are always incomplete. Biological molecules need a hand – and, again, that help comes from metals in the environment. "All life depends on metals," says Xavier. She argues that the central

The Miller-Urey experiment spontaneously produces the building blocks of life



US DEPARTMENT OF ENERGY/SCIENCE PHOTO LIBRARY

"The biggest clue may have been staring us in the face all along"

importance of metals is just one of the ways life depends on its environment to survive.

Other researchers also now emphasise the need to place the origin of life into its environmental context. "You cannot separate life from the planet," says Kaçar. Indeed, one of the biggest shifts in origins research in recent decades has been away from simply mixing chemicals in water, Miller-style, and towards experiments that more closely simulate a four-dimensional environment, one with a shape and surfaces that change over time. Proposed environments include a geochemical pool on land exposed to ultraviolet sunlight, the edges of which dry out in the sun and then become wet again when it rains, and the interior of a deep-sea hydrothermal vent where complex mixtures of chemicals flow up from beneath the seabed.

Finally, some researchers are also now acknowledging that the biggest clue to life's origins may have been staring us in the face all along: life is a community. Today, all organisms depend on others for their survival. This suggests we should stop focusing on the origins of the first organism and instead consider the origins of the first ecosystem. It is possible, thinks Xavier, that this primordial ecosystem had a three-dimensional structure – like the sticky biofilms that form when bacteria gunk up pipes – and that, at first, there were no individual cells.

If reconstructing the first organisms is difficult enough, it is nothing compared to the challenge of reconstructing primordial ecosystems. As such, it is likely that the origins of life will continue delightfully puzzling us for many decades to come. "If you understand the magnitude of the problem, it only makes you humble," says Kaçar. ■



Michael Marshall is a journalist and author of *The Genesis Quest*. He is based in Devon, UK



PETE REYNOLDS

I HAVE been writing on the internet for more than two decades. As a teenager, I left a trail of blogs and social media posts in my wake, ranging from the mundane to the embarrassing. More recently, as a journalist, I have published many stories about social media, privacy and artificial intelligence, among other things. So when ChatGPT told me that my output may have influenced its responses to other people's prompts, I rushed to wipe my data from its memory.

As I quickly discovered, however, there is no delete button. AI-powered chatbots, which are trained on datasets including vast numbers of websites and online articles, never forget what they have learned.

That means the likes of ChatGPT are liable to divulge sensitive personal information, if it has appeared online, and that the companies behind these AIs will struggle to make good on "right-to-be-forgotten" regulations, which compel organisations to remove personal data on request. It also means we are powerless to stop hackers manipulating AI outputs by planting misinformation or malicious instructions in training data.

All of which explains why many computer scientists are scrambling to teach AIs to forget. While they are finding that it is extremely difficult, "machine unlearning" solutions are beginning to emerge. And the work could prove vital beyond addressing concerns over privacy and misinformation. If we are serious about building AIs that

learn and think like humans, we might need to engineer them to forget.

The new generation of AI-powered chatbots like ChatGPT and Google's Bard, which produce text in response to our prompts, are underpinned by large language models (LLMs). These are trained on mountains of data, most of which is scraped from the internet – from social media posts to about 250,000 books and nearly all publicly available information, including news websites and Wikipedia pages.

From this, they learn to spot statistical patterns, which means they can predict the likeliest next word in a sentence. They function remarkably well, producing fluent answers to our every query.

The trouble is that the way AI chatbots work means that when they learn something, it can't be unlearned. LLMs generate their responses based on aggregated data, so there is no easy way for them to forget or "delist" specific pieces of information, as search engines like Google can, or even for individuals to track down exactly what an AI app knows about them, says David Zhang, an AI researcher and engineer at CSIRO, Australia's national science agency.

This creates a significant problem when it comes to privacy, as Zhang and his colleagues made clear in recent research. They highlighted how difficult it will be for AI companies to comply with the "right to be forgotten", which the European Union declared a human right back in 2014. ➤

Machine unlearning

With concerns that AI-powered chatbots could reveal private data, computer scientists are scrambling to teach machine-learning models how to forget, says **Shubham Agarwal**

*"Hackers can
trick chatbots
into behaving in
all manner of
unintended ways"*

Under the EU's General Data Protection Regulation (GDPR), people have the right to request that their personal information be removed from an organisation's records. Typically, on the internet, it is enforced in a variety of scenarios: not only do you have an undo button for your personal online content, such as social media posts or a public journal entry, but people also have the option to ask companies like Meta to offload the data they have collected about them. But such solutions aren't compatible with AI chatbots, says Zhang. "Not offering a way to delete or forget data from their models' memories is not upholding an individual's right to erasure."

The companies behind AI chatbots are going to have to find a way to deal with the issue, however, especially as LLMs begin to be trained on more sensitive information,

such as medical data, email inboxes and more, says Florian Tramèr, a computer scientist at ETH Zurich.

It gets worse, though, because AI-powered chatbots are also vulnerable to attacks in which information is concealed in the training data to trick the model into behaving in unintended ways. Security researchers have shown that this technique, known as "indirect prompt injection", can be used to get chatbots to run code remotely on users' devices, for example, or ask them to hand over their bank account details. GCHQ, the UK's intelligence agency, has called attention to the problem. But the risks from malicious prompt injection are only set to increase.

The good news, given the dangers, is that the work to figure out how to selectively delete information from an AI's knowledge base has begun. The bad news is that it is far from straightforward.

Induced amnesia

AI companies currently rely on band-aid fixes like "machine silencing", where they program their services to block access to certain information and withhold responses. "I'm very sorry, but I can't assist with that request," says ChatGPT, for example, when I ask it to build a personal dossier on me. This approach can work to an extent, says Luciano Floridi, the director of Yale University's Digital Ethics Center. But the target data is still there, he

stresses, which means there is always the risk that it will surface in responses as a result of glitches or malicious interventions.

The difficulty is that the most obvious way to induce amnesia in LLMs, namely to retrain the models with specific data points removed, is wildly impractical. It takes weeks of computation. What we really need to figure out is how to remove, or at least mask, specific pieces of information without having to retrain the model from scratch, says Yacine Jernite at AI firm Hugging Face. "It's a fantastic research problem."

Work towards solutions began in 2014, when Yinzhi Cao, then at Columbia University in New York, came up with a simple fix: rather than training the algorithm on the entirety of the available data, you break down what the algorithm learned from it into a series of smaller pieces known as summations. That way, when a person requests some information to be removed, you only have to modify the summation housing the data in question, dramatically reducing computation costs.

The principle is sound. But Cao's particular method only worked for models that were far simpler than the LLMs behind today's AI chatbots. In these new LLMs, fragments of data are so deeply intertwined that even isolating them down to a summation is unfeasible, says Cao, now at Johns Hopkins University in Baltimore.

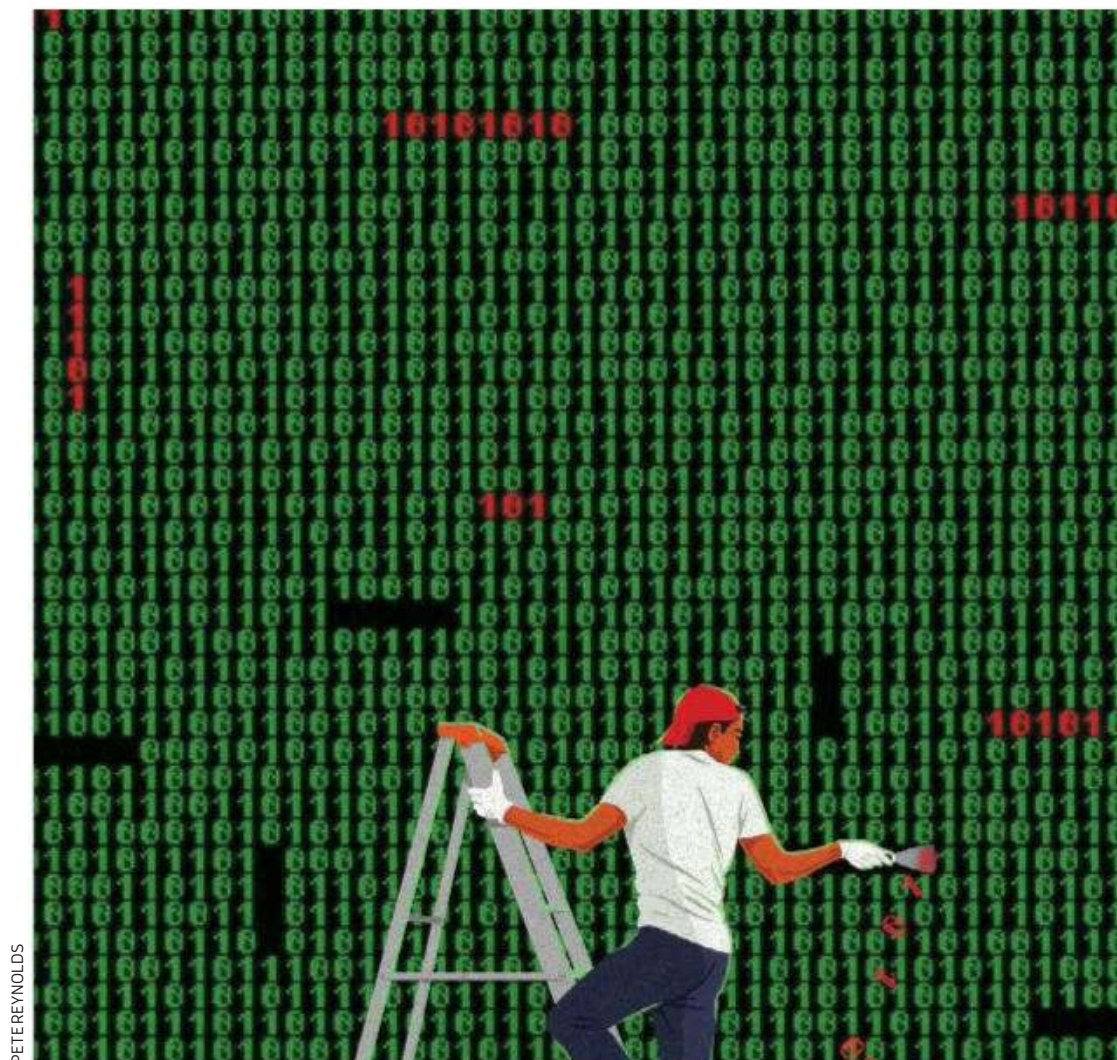
Another method was put forward in 2019 by Nicolas Papernot at Toronto University in Canada and his colleagues. Known as sharded isolated sliced aggregated (SISA), it works with the more complex artificial neural networks behind many LLMs, and makes it easier to locate and delete specific data points. It splits datasets into various smaller chunks, and the model is trained on each separately before the results are combined. It saves its progress like checkpoints in a video game as it goes from one chunk to another. When it is faced with an unlearn request, it can return to a checkpoint, cut off the chunk that houses the data in question and retrain from there.

When Papernot and his team tested SISA training on two large datasets – one containing details of some 600,000 home addresses, another with 300,000 purchase histories – they found that it significantly sped up retraining compared with doing it from scratch.

**AI companies will
struggle to comply with
the right to be forgotten**



ESTELLE LAGARDE/MILLENNIUM IMAGES, UK



PETE REYNOLDS

"We need to figure out how to remove data without having to retrain the AI from scratch"

SISA isn't without problems, not least the fact that it could have a big negative impact on the AI's performance. But the principle at its core has since inspired numerous iterations. In 2021, Min Chen at the CISA Helmholtz Center for Information Security in Saarbrücken, Germany, methodically divided and merged data – rather than doing so randomly, as in SISA training – to more effectively unlearn data without compromising too much in terms of the AI's performance.

Elsewhere, other groups are taking a slightly different approach. Because deleting data can be so detrimental to a machine learning model's performance, some have instead chosen to hide or obscure the relevant data so that it can't be extracted. Researchers at Microsoft and at Ohio State University, for instance, introduced noise into the information used to train a model in such a way that its subsequent outputs were

shaped by broader patterns in the data rather than specific, identifiable examples. "This provides a theoretical guarantee that the model won't reveal specifics about individuals in the training data," says team member Xiang Yue at Ohio State University.

Such generalisation tends to undercut some of the statistical learning prowess that makes AI chatbots so powerful. To circumvent that problem, Minjoon Seo at the Korea Advanced Institute of Science and Technology in South Korea and his colleagues chose a post-hoc approach. With their method, which they call "knowledge unlearning", the idea is to reverse the influence a piece of data had on the algorithm instead of deleting it altogether, so that the chatbot never references it. Knowledge unlearning has emerged as one of the most promising leads in this field, since it does the job with far fewer computing resources in less time,

and works on a slightly older counterpart of the underlying design behind ChatGPT.

The truth is that there is no frontrunner in the machine unlearning race. Google has organised a contest to reward those who can come up with efficient solutions, which not only demonstrates the importance of the challenge, but also suggests we might soon have a better idea of which methods could ensure we have a new generation of LLMs that can forget what they have learned.

Selective memory

That is a goal worth pursuing because it could have broader implications than concerns over data protection and malicious misuse of AI chatbots, says Ali Boyle, a philosopher at the London School of Economics who works on AI. Although the human tendency to forget is often viewed as a cognitive glitch, it can sometimes be beneficial, since we don't need to retain every piece of information we learn. By forgetting certain things, we make the process of retrieving the useful memories more efficient. The same might be true of AI systems, says Boyle.

She has argued that the principle was demonstrated in 2017, when researchers at Google DeepMind developed an AI that could play multiple Atari video games. It was effective at generalising its knowledge because, rather than learning in real time from its stream of experience, it stored memories of its game play that it could recall and learn from later. That is tantamount to memory, of course. But the researchers then refined the model such that it preferentially stored and recalled "surprising" events that diverged from its predictions – forgetting the rest of the data – and saw the system's performance improve.

The implication is that for an AI, selectively forgetting can improve performance. The trick is to find the right balance between remembering too much and too little. But if the ultimate goal for AI researchers is to build systems that learn and think like humans, which was certainly one of the original targets for the field, then we need to design them to selectively forget. "Forgetting is not a design flaw," says Boyle. "It is a design feature of an efficient, well-functioning memory system." ■



Shubham Agarwal is a technology journalist based in Ahmedabad, India

Puzzles

Try our crossword, quick quiz and logic puzzle **p45**

Almost the last word

Why don't marine mammals like whales get "the bends"? **p46**

Tom Gauld for *New Scientist*

A cartoonist's take on the world **p47**

Feedback

Hemisphere-based hair and the meaning of "psychology" **p48**

Twisteddoodles for *New Scientist*

Picturing the lighter side of life **p48**

Debunking gardening myths

Feeling the humidity

Is there any point in misting the air around your houseplants?

James Wong conducts a home experiment to find out



James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

MISTING the air around houseplants such as maidenhair ferns and pitcher plants has long been seen as essential to protect these species, which evolved in steamy rainforest understoreys, from the draughts and dry air of the average home. It is a practice that is so widespread, echoed in almost every indoor gardening book of the past century, it seems no one has stopped to ask: is there any evidence this actually works?

Standard advice is to give your plants a quick spritz between one and three times a week. However, given the average spray with a home mister contains just 1 millilitre of water, I have always been sceptical that 1 to 3ml of moisture a week can make a meaningful difference. The fact that not a single study on this in the context of a home appears to exist in the published scientific literature inspired me to take matters into my own hands. I bought a handful of humidity meters and got spritzing, stopwatching and spreadsheeting.

As I suspected, a generous spritz was effective at raising ambient humidity, but only for a short period. It immediately boosted the levels around a selection of plants in my warm living room from 50 to 70 per cent – the ideal level for some of my plants. However, within 30 minutes or so, this had returned to baseline. Just 10 minutes after I spritzed, almost half of the benefit had been obliterated. In my drier bedroom (35 per cent humidity), a repeat of the test showed similar results, but



CHRISTIAN BRIDGWATER/ALAMY

the return to baseline happened in just under 20 minutes.

Now, although I repeated both trials three times to ensure they were consistent, the results would vary enormously depending on the size of the room, its ventilation, its temperature and so on. But my experiment suggests you would have to mist not three times a week, but closer to three times an hour to make any meaningful difference. Plants that need high humidity are therefore best grown in terrariums, whose glass walls are designed to seal moisture in, or sited in groups on trays of pebbles filled with water, which continually evaporate moisture over a few days.

But do my colleagues in horticultural science agree? Alistair Griffiths, the Royal Horticultural Society's director

of science and collections, says: "There are many external environmental influences created by growing a plant in an indoor room, which are highly likely to override any improvements in the humidity surrounding your houseplants by misting them a couple times a week." Rogier Van Vugt, head of horticulture at the University of Leiden Botanic Gardens in the Netherlands, adds that indoor gardeners "should just pick plants that require lower humidity rather than permanently risking ruining their books and wallpaper". Horticulturists aren't known for sugarcoating their facts. ■

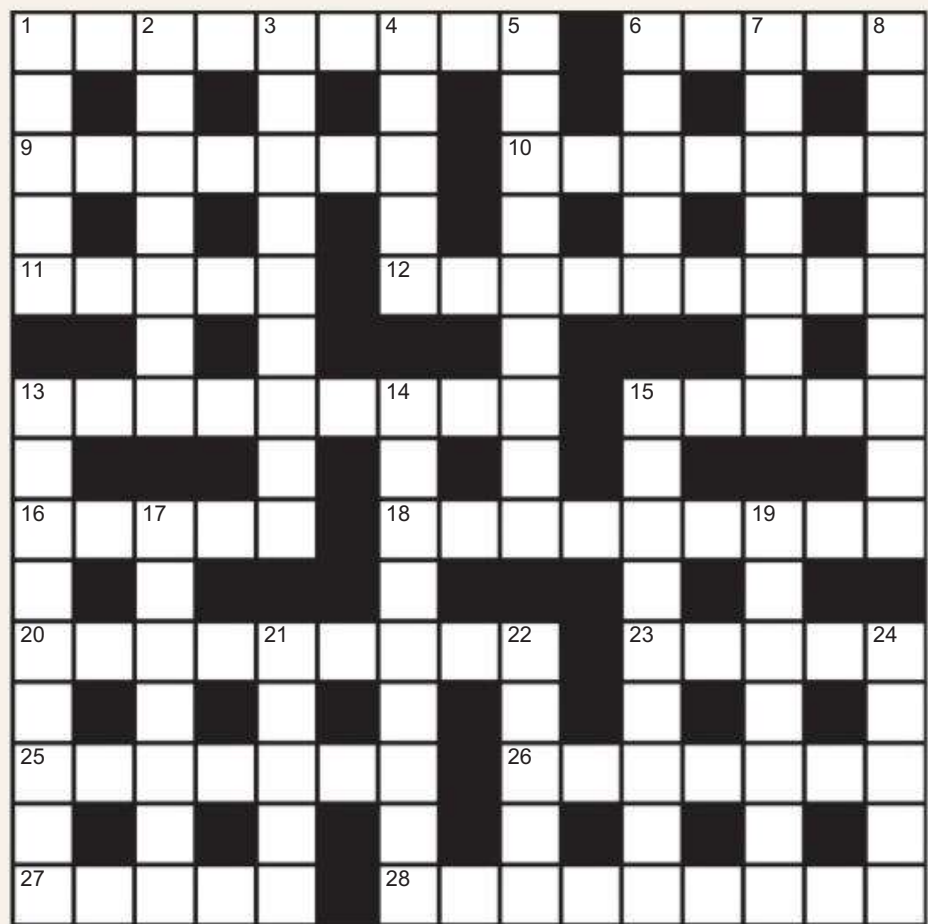
Debunking gardening myths appears monthly

Next week

Science of cooking

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Quick crossword #145 *Set by Richard Smyth*



**Scribble
zone**

Answers and
the next cryptic
crossword
next week

ACROSS

- 1** Fracture of the femur, perhaps (6,3)
6 Wens (5)
9 Rotating axis (7)
10 Wool grease (7)
11 Pasteur, Blériot or de Broglie, say (5)
12 Sequence of phases in the existence of an organism (4,5)
13 1793 invention of Eli Whitney (6,3)
15 Pointed scalpel (5)
16 John ____, English physician and philosopher (5)
18 Disease-causing agent classified as enteric cytopathic human orphan? (9)
20 Seaweed genus (9)
23 Derive through reasoning (5)
25 What remains after combustion or evaporation (7)
26 Pass water (7)
27 Subatomic particle (5)
28 Intestinal inflammation (9)

DOWN

- 1** Minimum (dose, perhaps) (5)
2 Fallopian tube (7)
3 Device for internal examination (9)
4 Charles ____, 19th-century Scottish geologist (5)
5 Songbird, *Carduelis carduelis* (9)
6 In the shape of a dunce's cap (5)
7 Si (7)
8 Unconscious; idiotic (9)
13 First milk (9)
14 Type of monochrome image (9)
15 Antoine ____, chemist guillotined in 1794 (9)
17 Cadavers (7)
19 Deflect or redirect (rays of light) (7)
21 Supplementary component (3-2)
22 Shed feathers or fur (5)
24 Rushes (5)

Quick quiz #226

set by Bethan Ackerley

- 1** Stan Franklin and Bernard Baars are associated with which theory of consciousness?
2 Convection cells in the photosphere of the sun are also known as what?
3 What name is given to the largely organic detritus that sinks to lower layers of the ocean?
4 The last known individual of which species died in Hobart Zoo, Australia, in 1936?
5 Which of the following isn't a kind of anthocyanin: pelargonidin, malvidin or naringenin?

Answers on page 47

Headscratcher

set by Daniel Griller
#246 Monoglots

At an international conference of the utmost import, there are 1000 delegates present. Rarely has such a linguistically talented company assembled: half speak English, half French, half Greek, half Mandarin and half Hindi.

I hate these conferences. It's all double-talk and snobbery over canapés. Worst of all, I am fluent in nothing but English.

I would do well to seek out the other poor souls whose linguistic capabilities are similarly capped at one. Not that I could talk to all of them, obviously. But I would understand their plight.

Perhaps it's just me. Then again, perhaps my little club isn't so little after all...

What is the greatest possible number of delegates that speak exactly one language?

Solution next week



Our crosswords are now solvable online
[newscientist.com/crosswords](https://www.newscientist.com/crosswords)

Deep dive

Why don't marine mammals like whales get "the bends"?

Stephen Johnson

Eugene, Oregon, US

Diving mammals don't get the bends, or decompression sickness, because they don't breathe compressed gases – or any gases for that matter – when they dive.

Decompression sickness is caused by the absorption of soluble gases in body tissues during diving. Because the pressure under water is greater than at the surface, these tissues strive to reach equilibrium with the outside water pressure. Humans can breathe while underwater through the use of compressed gas tanks. This gives humans an enormous exposure to nitrogen and other soluble gases. When a diver returns to the surface, these gases can form dangerous bubbles as they leave the body. Because of this, human dive times and depths are severely limited, while diving mammals

"Miners in the 19th century often developed symptoms that caused them to hunch over, hence the term the bends"

can reach depths of hundreds, sometimes thousands, of metres and stay there for long periods.

Diving mammals do all of their dives on a single breath of air. In fact, many exhale before diving. In addition, when sea mammals dive, their lungs are compressed, which drastically reduces the ability of the blood to pick up air. Instead, diving mammals store extra oxygen in their bloodstream and muscles. As a percentage of body weight, diving mammals have about three times as much blood as humans do. They also have a higher percentage of the oxygen-transporting protein haemoglobin in their blood: a whale's blood is around 60 per cent haemoglobin,

versus around 30 per cent in humans. Their muscles can store significant amounts of oxygen too, as they have eight times as much myoglobin, a protein that does this, as human muscles.

The bends, or caissons disease, was first discovered in the 19th century when hard rock mines reached depths that required the air supply to be significantly compressed. These early miners, or caissons, often developed symptoms that caused them to hunch over on their return to the surface, hence the term the bends. The illness is treated with oxygen at high pressure.

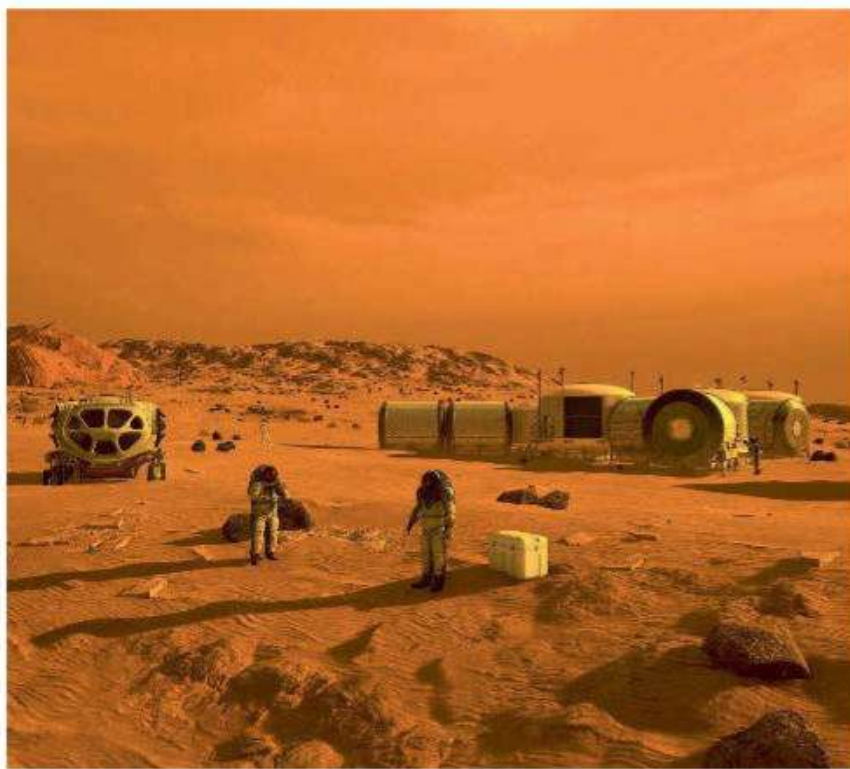
Mike Follows

Sutton Coldfield, West Midlands, UK
Actually, marine mammals can get decompression sickness, but their

physiology largely protects them. To answer this question fully, it is perhaps best to start with why humans are so susceptible.

The pressure in a column of fluid increases as you move down through it. There is 1 atmosphere of pressure at sea level because of the weight of air pressing down from above. Water pressure increases by 1 atmosphere for every 10 metres of descent. For example, at a depth of 30 metres, the pressure is four times atmospheric pressure and scuba divers breathe air at this pressure. Even if air at atmospheric pressure could be delivered to divers, the surrounding water pressure would prevent their lungs expanding and they would suffocate.

Air dissolves in the bloodstream, which is how gases are moved



STOCKTREK IMAGES, INC./ALAMY

This week's new questions

Life on Mars What is the minimum number of working individuals that would be necessary for the survival of a settlement on Mars? *Howard Ritter, Perrysburg, Ohio, US*

Left or right Why aren't we equally capable with our left and right sides? Wouldn't this have given us a survival advantage? *Celine Szoges Schwartz, Thornbury, Ontario, Canada*

How many working people would be needed for a Mars settlement to survive?

around the body so that oxygen can be delivered to cells and carbon dioxide can be removed. Nitrogen in the air is also absorbed by the body tissues, as it is five times as soluble in fat as in water. As a scuba diver ascends, the pressure decreases and nitrogen comes out of solution. Bubbles of nitrogen gas can form if the ascent is too rapid. These can cause injury. Divers ascend slowly so their blood can surrender the nitrogen gas to the lungs, from where it can be safely exhaled.

When I started diving, it was assumed that decompression sickness was impossible for breath-hold divers, which includes freediving humans (who dive without scuba gear) and marine mammals that dive on a single breath taken at the surface. Except for a reduction in oxygen and an increase in carbon dioxide, it was thought that the exhaled air would be identical to what was inhaled. It was believed there would be no reason for bubble formation because air wasn't being inhaled at higher pressure during the dive.

This changed in 2002 with the mass stranding of 14 whales in the Canary Islands. They all showed symptoms of decompression sickness. The stranding was close to a naval military exercise where acoustic sonar was being used. It is thought that the whales made a rapid ascent to escape the sound. Subsequent research has shown that deep-diving whales collapse half of their lungs to reduce the reservoir of nitrogen that can be absorbed into their tissues.

The absorption of nitrogen increases with pressure, dive duration and the supply of nitrogen. The Cuvier's beaked whale (*Ziphius cavirostris*) can dive to almost 3 kilometres, exposing it to 300 times the pressure experienced at the surface. A diving whale experiences 100 times the pressure that scuba divers do when they dive



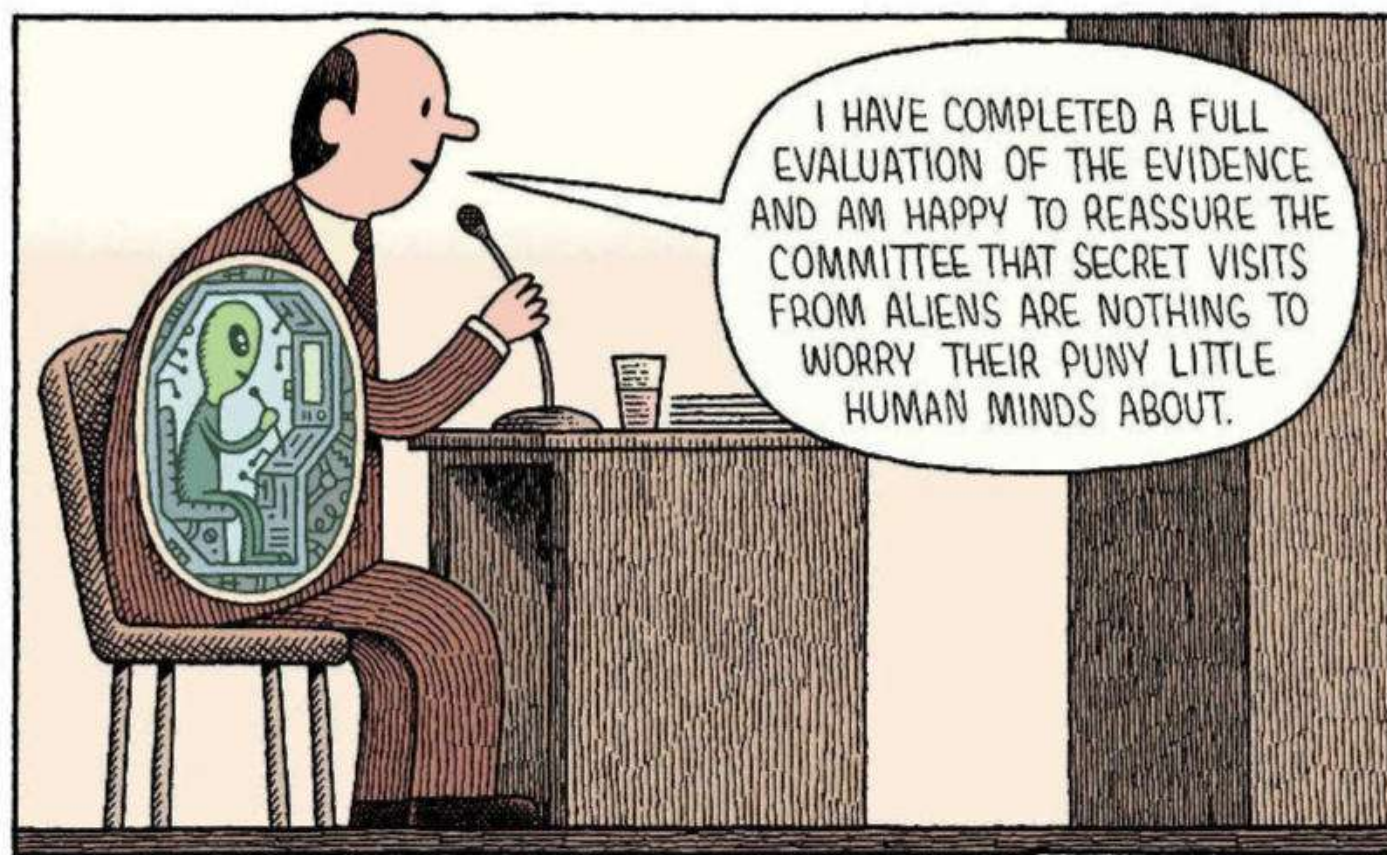
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Tom Gauld
for *New Scientist*



to a depth of 30 metres. However, while whales take a single breath before they dive, scuba divers breathe compressed air in order to stay submerged for around an hour, which increases the volume of air passing through their lungs (and their exposure to nitrogen) by a factor of about 400. This makes humans more susceptible than whales to decompression sickness even before any evolutionary adaptations.

Moonlight spotlight

When was it first realised that the lit portion of the moon always faces the sun, so moonlight must be reflected sunlight? (continued)

Eric Kvaalen

Les Essarts-le-Roi, France

Previous correspondents James Ladyman and Kelli Rudolf quote philosopher Parmenides as saying that the moon is a “night-shining, foreign light, wandering around the Earth”. But Parmenides also said, speaking of the moon’s size, that it was equal to the sun, for it

“With a chihuahua, my labradors sniffed and then lost interest, as if to say: ‘Looks like a dog, but doesn’t smell like one’”

is illuminated from it. This opinion is reported by historian Eusebius (see *Praeparatio evangelica*, Book 15). Eusebius reports that philosopher Thales and his followers also said that the moon is illuminated from the sun. Thales was around earlier than Parmenides, living through the first half of the 6th century BC. Both Thales and Parmenides were earlier than Anaxagoras.

Two of a kind

How do dogs recognise that another animal is also a dog when there is such a vast array of canine shapes and sizes? (continued)

John Dobson

Allendale, Northumberland, UK

Both my current and most recent

previous dogs were labradors and both behave(d) in the same way when meeting a chihuahua. The initial response was sniffing. In both cases, my dogs immediately lost interest, as if to say: “Looks like a dog, but doesn’t smell like a dog, so it’s not a dog.”

So, smell probably has a lot to do with mutual recognition.



Blaise Bullimore

Haverfordwest, Pembrokeshire, UK

The picture above is possibly an extension, rather than an answer, to the question.

This is my golden retriever Cai, who has clearly recognised the skeleto-canine for what it represents, and is exhibiting the appropriate investigatory behaviour! ■

Answers

Quick quiz #226

Answers

- 1 Global workspace theory
- 2 Granules
- 3 Marine snow
- 4 The thylacine, or Tasmanian tiger (*Thylacinus cynocephalus*)
- 5 Naringenin

Cryptic crossword

#121 Answers

ACROSS 1 Ragweed, 5 Match, 8 Tulip, 9 Ladders, 10 Rose cut, 11 Assay, 12 Employ, 14 Picnic, 17 Tiara, 18 Operand, 20 Rhenium, 21 Atoll, 22 Wrong, 23 Cryptid

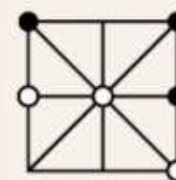
DOWN 1 Retiree, 2 Gales, 3 Expectorating, 4 Dilute, 5 Media literacy, 6 Treason, 7 Husky, 13 Placebo, 15 Coddled, 16 Cosmic, 17 Threw, 19 Adopt

#245 Three men’s

morris

Solution

Alpha can win in four more moves. Let’s say she puts her piece on centre left. The next moves are forced. Zoe must block with centre right, Alpha follows with bottom right, then Zoe blocks Alpha at top left. Alpha can now move either of her pieces on the middle row to the bottom, and Zoe can’t move to block the bottom line.



Zoe would have lost just as quickly if she had started with middle top (or any corner or middle junction). This is why it is good to have an extra rule that the first player can’t put their piece in the centre. With that rule, it turns out “perfect” play will always end in a stalemate, like in noughts and crosses.

Southern hair whorls

Three northern hemisphere scientists – Marjolaine Willems, Quentin Hennocq and Roman Hossein Khonsari in Paris, France – teamed up with a southern hemisphere scientist – Juan José Cortés Santander in Santiago, Chile – for a study they call “New insights on the genetics of hair whorls from twins and the southern hemisphere”.

“We obtained unexpected results,” they say. What they found, should it prove accurate, adds a twist to earlier research about how, and maybe why, hair swirls this way or that on a person’s scalp.

First, they present some expected results, giving partial credit to parents: “we report observations on twins suggesting that the morphological parameters of whorls have genetic bases...” Then they serve up their parent-less surprise: “... and provide comparative data on whorls from children born in the Northern and Southern hemispheres, indicating that whorl formation also depends on environmental factors.”

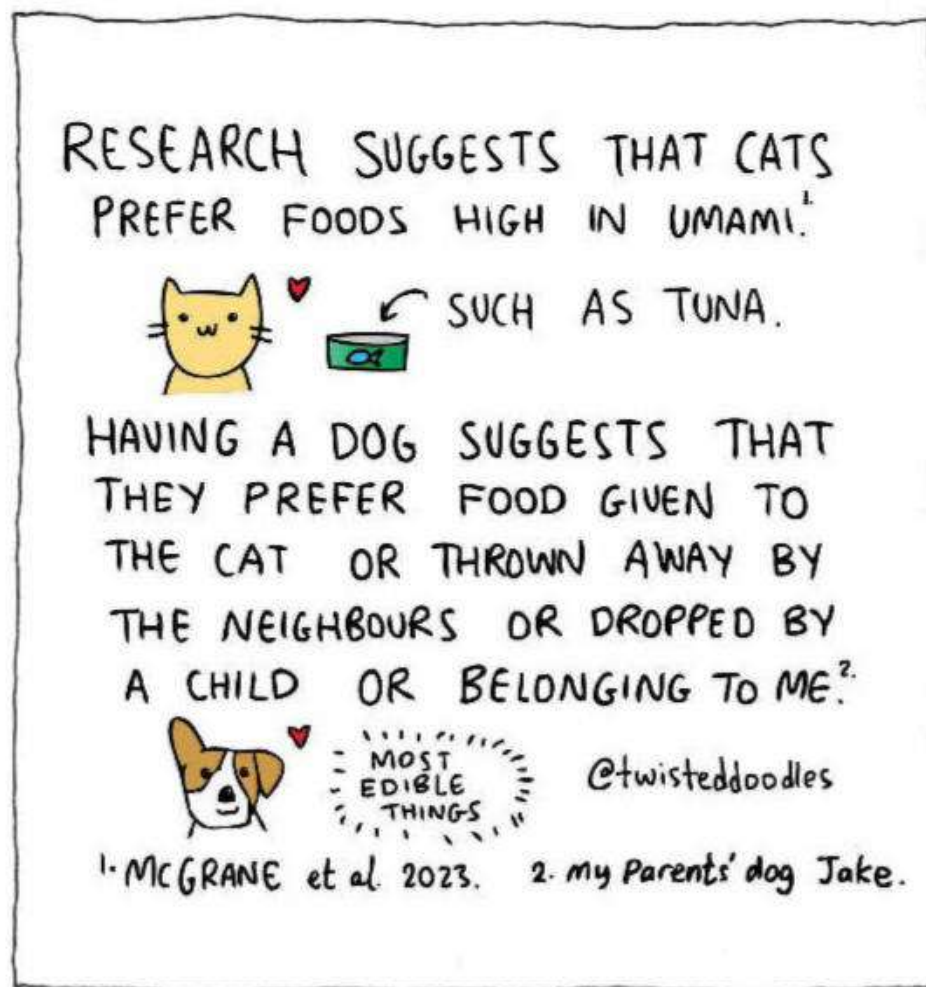
Willems, Hennocq, Cortés Santander and Khonsari avoid going into much detail about the factors. But they do hint at a possibility, a line of reasoning familiar from a zillion schoolroom discussions as to whether bath water swirls clockwise or counterclockwise as it whooshes into a drain.

The team does some hair-raising with that reasoning, by substituting hair for water. Acknowledging some vagueness, they say: “A higher prevalence of counterclockwise whorls in the Southern hemisphere underlined the potential role of environmental factors, such as external physical constraints. It was not clear whether this hemispheric effect on rotation direction could be related to the Coriolis force.”

Come rain or shine

Though produced in a land famous for damp and gloomy weather, the UK-based *Quarterly Journal of the Royal Meteorological Society* is not

Twisteddoodles for New Scientist



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Consideration of items sent in the post will be delayed

without Sun and Shine. Steve Rothman alerted Feedback to the cheery fact that in 1994, the journal published a paper by two scientists at the University of Reading, UK. The paper is called “Studies of the radiative properties of ice and mixed-phase clouds”. The scientists are called Zhian Sun and Keith P. Shine. It is a classic case of nominative determinism.

Feedback notes that eight years later, another Sun and another Shine shed light on a different subject. Richard Shine and two colleagues at the University of Sydney, Australia, teamed up with Li-Xin Sun at the Snake Island-Laotie Mountain Biosphere Reserve, near Dalian in eastern China, to write a paper called “Thermal correlates of foraging-site selection by Chinese pit-vipers (*Gloydius shedaoensis*, Viperidae)”. This Sun and Shine focused only

briefly on weather, remarking that pit vipers, which rely on immobility to conceal themselves from both predators and potential prey, “cannot move about to track temporal shifts in weather conditions”.

More recently, a third Sun – Xiaochen (Andy) Sun, affiliated with a Californian company called LaXense – co-wrote a study about SHINE, or the “Seamless Hybrid-Integrated Interconnect Network”.

Soon thereafter, a fourth Sun – Jiuce Sun at the Chinese Academy of Science – co-authored a paper about a second SHINE, the “Shanghai High repetition rate XFEL and Extreme Light Facility”.

Sun and Shine followed Sun and Shine. Then came Sun. Then came Sun.

Through it all, the weather in the UK remained primarily gloomy and damp.

Quantum thinking

The field of psychology has a basic problem: almost no two psychologists seem to agree on an exact definition of “a thought”. Or an exact definition of love, happiness, sadness, hate or other main concepts – call them “states of mind” – that psychologists study. Because of that, no two psychologists can be confident that when they use the same word, they are both talking about the same thing.

That has always made it difficult for psychologists to use maths or physics to analyse, with much precision, almost anything about how people think and feel.

The difficulty hasn’t delayed them from trying.

Now a mathematics professor, Dorje C. Brody at the University of Surrey, UK, is taking a stab at it with his paper “Quantum formalism for the dynamics of cognitive psychology”.

He explains: “The present paper is concerned with the use of Hilbert space techniques, so successfully implemented in characterising behaviours and properties of quantum systems, to model cognitive ‘psychology’...” Brody then explains what he means when he writes – and puts quote marks around – the word “psychology”.

“My main contribution,” he says, “is to introduce a formalism that allows for a systematic treatment of the dynamics of the cognitive state of mind, from which predictions can be made about human behaviour.”

Precisely. Brody’s quantum research quest could invigorate people’s thinking about thoughts, whatever those may be.

Quantum depression

“We believe that our study will serve as a reference for researchers studying similar topics,” say the authors of a physics preprint called “Using quantum computing to find out why students are depressed”.

They may be correct. ■
Marc Abrahams

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